MECHANICAL ENGINEERING

INCLUDING THE ENGINEERING INDEX

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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CHARLES M. SCHWAB.

JANUARY 1927

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* * * * *

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During this period he acted also as engineer (part time) to the Home Office. He also acted as consulting engineer in power heating and other problems for Belfast, Sheffield, and Manchester firms from 1910 to 1913. During the war he served as lieutenant R.N.V.R. and received an award by the Royal Commission on Awards to Inventors for Secret War Inventions. He was appointed assistant to the Director of Fuel Research and Superintendent of the Physical and Chemical Survey of the National Coal Resources in 1920; in 1922 he was made Deputy Director of Fuel Research and in 1923 Director.

* * * * *

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* * * * *

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* * * * *

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* * * * *

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* * * * *

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MECHANICAL ENGINEERING

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Recent Developments in the Science of Coal Utilization

Second Robert Henry Thurston Lecture on the Relation Between Engineering and Science

By CECIL H. LANDER, D.Sc.,[1] LONDON, ENGLAND

C. H. LANDER

IT MAY truthfully be said that the practice of mechanical engineering deals with two classes of raw material, namely, metals and fuels; for while the former is essential to the construction of the machines which bulk so largely in the practice of mechanical engineering, these machines would in the main be useless without the fuel necessary to drive them. It appears to the speaker that it is peculiarly fitting that the second of the series of lectures instituted to honor the memory of Robert Henry Thurston should be devoted to the interrelation between the science and engineering of coal utilization, the first having been devoted to similar relations between engineering and science in the metal industry.

It is interesting to refer to the James Forrest lecture given before the Institution of Civil Engineers in June, 1921, by the late Sir George Beilby, who took for his subject Fuel Problems of the Future, and to note how in the short space of five years several applications of science which at that time appeared to be visionary have now almost become practicable and commercial propositions.

On the other hand, certain problems enunciated in that address are still engaging the attention of technicians and scientists who, although they have made great progress in their solution, have not yet provided the complete answer. As the conditions in Great Britain are more familiar to the speaker than are those of the United States, he trusts he will be forgiven if he uses data obtained in the former country rather than in the latter to emphasize any point which he wishes to make.

In most of the countries of the world the amount of coal which is burned in the natural state is far greater than that which is subjected to preliminary operations of carbonization and gasification. Beilby, in his lecture mentioned above, pointed out that—

> The greatest of the fuel problems of the future is to decide what proportion of this huge total it will pay to subject to a preliminary operation of carbonization or gasification, with the object of sorting out the potential thermal units of the coal into groups of higher availability or greater convenience as fuels, for instance, gas, motor spirit, fuel oils, and coke.
>
> Though the operations of carbonization and gasification involve the expenditure and loss of some of the thermal units of the coal, so that the collective thermal value of the new fuels is less than that of the original coal, yet the loss may be more than compensated for by the increased value of some of the new fuels.

The science of coal utilization thus deals with the stepping up of the thermal availability of the raw coal, and no avenue should be left unexplored which may lead to improvements in our methods of coal utilization. The study must commence with the raw material, and may even involve speculations as to events and happenings of millions of years ago.

The Constitution of Coal

No apology is therefore required for touching briefly on the subject of the constitution of the coal substance itself. Although coal is so widely spread and has been utilized for many centuries as a source of heat, light, and power, it is unquestionable that the scientific study of this important mineral has been sadly neglected. It is only comparatively lately that the number of scientific workers who have been studying the different aspects of its constitution has been at all commensurate with the importance of the subject. The research has also suffered by taking the form of isolated experimentation in various parts of the world, and only lately has there been any tendency for workers of scientific attainment to make a combined attack upon it. The fundamental reasons for the differences between the various types of coal have not yet been placed upon a really rational basis, and it is not yet possible to formulate any general laws which are strictly true. It may be that it will be found impossible to formulate such general laws, but a more intimate knowledge of its constitution cannot fail to be of the greatest value to the engineers and technologists responsible for its proper utilization. Such knowledge would assist in the solution of many problems relating to carbonization and other forms of conversion undertaken in order to raise the "availability" of the heat units contained within it, and would even help the combustion engineer to overcome some of the difficulties associated with the large furnaces and other appliances with which he has to deal.

The problem of the constitution of coal is one which, as Professor Bone[2] has pointed out, can be solved only by the application of the systematic methods of organic chemical research. Without wishing to define the position of the dividing line, if one exists, between the methods of the organic chemist and those of the technical chemist, it may be remarked that before applying to coal the ordinary systematic methods of organic chemistry the material must usually be subjected to some preliminary process of disintegration often possessing considerable technical interest. Among such processes may be mentioned (*a*) carefully regulated destructive distillation, (*b*) direct hydrogenation at high temperatures and high pressures (Bergius process), (*c*) controlled oxidation (used by Professor Wheeler), and (*d*) extraction by various solvents.

The last-mentioned process has been shown recently to throw considerable light on the coking qualities of the coals investigated, and in one instance has led directly to a special process of carbonization. This is the Parr process,[3] designed for producing a coherent coke from the coals of southern Illinois. Professor Parr used phenol, and subsequently xylene, as solvents. He found that the extract possessed caking properties absent in the residue, but that if the two were again mixed the coal regained its coking power. If, however, the residue had become oxidized by "weathering," then addition of the extract did not restore the coking power. On heating the "weathered" residue to 300 deg. cent. it lost a considerable volume of gas, principally oxides of carbon, and regained its power of coking when mixed with the extract. The extract itself did not suffer appreciable loss of coking quality on "weathering" or on *rapid* heating to 300 deg., but did on *slow*

[1] Director of Fuel Research, British Department of Scientific and Industrial Research.

Delivered at the Annual Meeting, New York, December 6 to 9, 1926, of The American Society of Mechanical Engineers.

[2] W. A. Bone, *Jl. Soc. Chem. Indus.*, vol. 44 (1925), 291–299T.

[3] S. W. Parr, *Jl. Ind. & Eng. Chem.*, vol. 18 (1926), pp. 640–648; cf. W. R. Chapman, *Fuel*, vol. 5 (1926), pp. 355–361.

heating. It follows that the coking power of a weathered coal may be restored by a preliminary rapid heating to 300 deg., and it is on this fact that the Parr process is based.

It may here be mentioned that preheating, involving possibly a very limited oxidation, may be of advantage when using some low-temperature carbonization processes with strongly swelling coals.

The work of Fischer[4] in Germany and of Bone in England on the extraction of coal with benzene under pressure (500–700 lb. per sq. in. at temperatures of 260–285 deg. cent.) is also closely concerned with the question of coking property. The extract is here further resolved by the process summarized in Table 1 (due to Bone).

TABLE 1 BENZENE COAL-EXTRACTION PROCESS

Concentrated solution of extract (7–11 per cent of coal) in benzene + light petroleum (boiling point, 40–60 deg.)

Soluble + benzene-free light petroleum		Insoluble + ethyl alcohol	
Soluble	Insoluble	Soluble	Insoluble
Fraction I	Fraction II	Fraction III	Fraction IV
Non-nitrogenous heavy oil	Red-brown solid, softening point about 25 deg.	Non-nitrogenous brittle resinous red-brown solid, softening point about 60 deg.	Nitrogenous amorphous brown solid, softening point 180–230 deg.

The coking propensity of a coal seems to reside in Fraction IV, which is able to confer pronounced binding properties on a powdered coke. Coals with less than 2 per cent of this constituent are non-coking, those yielding 2.5 per cent show incipient coking properties, while a strongly coking bituminous coal contains between 4 and 7 per cent. Oxidation of residue from the extraction by alkaline permanganate[5] gave a considerable yield of mellitic acid and benzene—1:2:3:4—tetracarboxylic acid, indicating that the coal substance possesses a six-ring carbon structure, each carbon of the ring being connected to other carbon atoms.

The method of regulated destructive distillation yields results for bituminous coals which are often difficult of interpretation owing to overlapping of the various decomposition processes. Professor Bone points out that it is easier to recognize and separate the distinct decomposition processes when brown coals are distilled. In this connection may be mentioned his recommendation that investigations of the constitution of coal should include a coordinated study of deposits of coal in which all states of the maturing of coal from peat to anthracite are represented.

The bearing of the results of the hydrogenation of coal on the general question of coal constitution has not as yet received investigation, but attention may be directed to the work of Heyn and Dunkel[6] in Germany, which seem to confirm Bone's views as to the six-ring carbon structure of the coal substance.

Finally may be mentioned investigations which endeavor to determine from what plant tissues the coal originated and the steps by which the plant material has been reduced to its present condition. These involve microscopic rather than chemical examination, although a combination of the two has been used by Professor Wheeler.[7] C. A. Seyler[8] has applied the methods of metallography to the problem, first polishing the coal surface, then etching it with a sulphuric-chromic acid mixture, and viewing it by reflected light under a magnification of 100–450 diameters. Considerable progress has been made in the interpretation of the structures observed. A striking type of structure, observed frequently in fusainized lenticles, is that known to petrologists as "Bogenstruktur" and is due to the fragmented cells of secondary xylem. Several other forms of plant tissue have been recognized by Seyler. The method appears to be preferable to that of preparing thin sections for investigation by transmitted light in that it is easy, rapid, and applicable to all kinds of coal.

According to Wheeler[7] bituminous coal consists essentially of insoluble ulmins in which organized plant tissues are dispersed. By mild oxidation (with hydrogen peroxide or with air at 100–150 deg. cent.), the ulmins are rendered soluble in alkali and may thus be separated from the organized plant material, leaving the latter in a form available for microscopic investigation. Fossil plant cuticles and other tissues have been recognized in this residue. The ulmins, when oxidized by dilute nitric acid, yield oxalic, succinic, picric, and pyromellitic acids, indicating that the ulmin molecules consist of benzenoid groupings linked together by such structures as pyrrole and furan or their derivatives.

Coal Analysis

In all questions of buying and selling coal, and in the utilization of coal, the problem of its accurate chemical analysis arises. This subject is especially pertinent to the export trade, since it is well known that the competition for the sale of coal in various countries is becoming increasingly keen. Consumers are demanding uniformity of quality, and in some cases are making their contracts on the basis of calorific value. In most of the countries in Europe where coal is either exported or imported there are well-equipped fuel laboratories, which in several cases are official organizations. In view of these facts it is becoming evident that some agreement as to the best methods of coal valuation must be arrived at between the chemists concerned. It is fairly obvious that the determination of the amount of ash in a sample of coal is a simple matter, but real difficulties are encountered in obtaining an average sample of coal when the conditions of loading differ from those prevailing when the coal is discharged. The very definitions of such values as the melting point of coal ash, the caking value of coal, the results from a carbonization assay, etc., which are in the present stage of our knowledge empirical conventions as distinct from exact chemical conceptions, require careful standardization.

It is well known that the available methods of analyzing and sampling coal have been examined by bodies of experts in America, and that standard conventions have been adopted. As you are aware, standard methods have also been published by other countries, but unfortunately these are sufficiently dissimilar to yield different values in the hands of analysts.

I cannot attempt on this occasion to deal critically with this important question, but I would suggest that the time has arrived when the methods of analysis should be made the subject of an international conference among the nations chiefly concerned with the sale of coal, and, further, that this conference should recommend methods of sampling and evaluation which would be acceptable to both producers and users in the various countries.

Our knowledge of the chemistry of coal advances rapidly and it would be necessary to review the standards at intervals, but I believe that any modification from time to time found desirable could be effected by correspondence. I may say that an international conference on coal analysis would meet the wishes of coal technologists of at least two European nations.

Perhaps I might add that the question of the determination of the melting point of coal ash is at present the subject of a joint investigation under the auspices of the Bureau of Mines and the Fuel Research Division of the Department of Scientific and Industrial Research in England. The objects of this investigation are to ascertain whether the methods used in the two countries will yield results of a similar order upon typical coals obtained from the two countries, and to attempt to perfect a simple method which would be suitable for practical requirements.

Preparation of Coal for the Market

At the present time the greatest interest is being manifested both by technologists and the general public in all methods by which coal may be transformed into gas, tar, or oil, while the production of metallurgical coke and smokeless fuel is receiving the closest attention. Certain aspects of these questions will be dealt with in the course of my lecture.

However, it appears strange to me that the scientific investigation of one subject, viz., the preparation of coal for the market, should have been so neglected. I do not wish to suggest that many firms are not thoroughly equipped for the adequate purification of their seams, but rather that scientists as a whole have failed to pay due attention to this important branch of coal utilization. Accurate data are required upon the physical and chemical properties

[4] Fischer and co-workers, *Brennstoff-Chemie*, vol. 6 (1925), pp. 33–43, 349; cf. *Jl. Ind. & Eng. Chem.*, vol. 17 (1925), p. 707.

[5] W. A. Bone and R. Quarendon, Proc. Roy. Soc., vol. A 110 (1926), pp. 537–542.

[6] Heyn and Dunkel, *Brennstoff-Chemie*, vol. 7 (1926), pp. 20, 81, and 245.

[7] R. V. Wheeler and co-workers. Several papers in *Jl. Chem. Soc.*, 1925 and 1926.

[8] C. A. Seyler, *Fuel*, vol. 4 (1925), pp. 56–66.

of coal and its impurities as a first essential to efficient and economical purification.

Preparation for the market involves a study of all processes of the treatment of the coal from the time it leaves the coal face until it is in the furnaces or retorts of the consumer. The ideal method of coal selling might in fact be compared with the "selling service" of certain motor cars. The consumer should be thoroughly well informed of the properties and characteristics of the product in relation to the particular way in which he proposes to consume it in his works. The factors to be considered are extremely diverse, but it is becoming increasingly evident that many of the difficulties encountered in economic purification may be associated with the proportion of fine coal and fine dirt present in the run-of-mine coal.

The investigations undertaken by the Bureau of Mines are well-known to you. A bulletin by Holbrook and Fraser (Bureau of Mines) deals with many interesting aspects of screening and sizing. Berrisford and Berrisford[9] in dealing with the problem of hand picking found that coal cannot be separated from dirt so efficiently in artificial light as in daylight, and suggest that lamps of light blue tint are more effective. Such a fact as this is of peculiar interest to practical men.

R. A. Henry[10] has attacked the question of the theory of coal washing. He considers that theories based upon the fall of a single particle in a liquid do not represent the actual conditions prevailing in coal washers. It is now generally recognized that so-called "hindered fall" plays an important part in a bed of coal and dirt during the washing process. Henry has, however, developed a new conception, termed by him the "Rudder Law," to account for the manner in which coal and dirt separate in various washeries. The principle is of considerable importance, and merits a closer study of the original articles. It has been applied by Henry to the construction of a complete washery of novel design in which the coal can be cleaned without previous sizing. The practical results of these large-scale plants will be awaited with considerable interest.

This same subject has been investigated at the Fuel Research Station, where observations have been recorded in which the shape of the particles and the stream of water have a relationship which suggests an application of the principles of aeronautics and aerofoils.

The study of coal seams by means of X-rays is yielding information of particular interest in connection with the purification of coal. This subject is being dealt with especially by Kemp, Maclaren, and Thompson of Edinburgh (Great Britain), and although the investigations are of relatively recent origin and the data somewhat incomplete, the utilization of X-rays for the examination of the products from washeries has in their hands proved of considerable practical value. These experimenters have devised an instrument termed a "carboscope" by which the products from a colliery may be rapidly inspected. Such visual examination enables a clear distinction to be drawn between the inherent ash of the coal and the impurities possible of separation by efficient methods of treatment.

When the information provided by this method is studied in conjunction with the specific-gravity curves of the various sizes of coal, a valuable impression is gained of the degree to which the coal can be purified. There is little doubt that if the technique can be brought to a reasonable cost, the coal technologist will be provided with a method of examining coal of great simplicity.

All processes for the purification of coal with water as a medium suffer from the inherent disadvantage that the water must be eliminated before the coal can be used in many industrial processes. The cost of drying coal increases broadly with the area of surface to be dried, and consequently the finer the state of division the more costly and difficult the processes become.

In Great Britain particular attention is being devoted to processes for drying coal, and although no general solution of the problem has yet been discovered, valuable experiments are proceeding on a large scale.

It is obvious that methods of purification which do not entail wetting the coal avoid many of the troubles associated with coal treatment, and it is on this account that processes of dry-cleaning coal are so eminently attractive. The principles involved in the various plants are numerous and it is not desirable for me to enter into a discussion of them, but one factor is patent, and that is the paucity of the data available upon the physical properties of coal seams and the shales and impurities associated with them.

[9] Trans. Inst. Min. E., vol. 69 (1925), p. 282.

[10] *Revue Universelle des Mines*, June 1, 1925; *Colliery Engineering*, 1925, p. 340.

Low-Temperature Carbonization

The scientific problems of the carbonization of coal are so multitudinous that only a brief summary of certain salient features can be attempted.

Certain definite principles have been followed in the development of the processes which are now undergoing technical and commercial exploitation. These are incorporated in the following types of units.

1. Vertical retorts without mechanical agitation of the charge.
2. Vertical retorts with mechanical agitation or movement of the charge.
3. Inclined retorts with or without mechanical disturbance of the coal by means of breakers, scrapers, etc.
4. Horizontal retorts with mechanical movement of the charge and agitation.

The method of heating the coal in the several processes may be by one or more methods:

1. External heating
2. Internal heating
3. A combination of the above.

The methods of treatment may be divided into two classes, depending upon the form in which the solid product of carbonization is obtained. The products of carbonization are smokeless fuel, low-temperature tar, and gas of high calorific value. It does not seem probable that ammonia will be obtained in sufficient quantities to warrant its recovery. In plants in which the solid product is obtained in the form of lumps, it is usually necessary for the charge of coal to be stationary for a sufficiently long period for it to have time to agglomerate. This effect may, however, be brought about by introducing the coal into the retort in such a compact form that it retains this form throughout the carbonization, or by subjecting it to compression during the carbonization process. It is necessary to place some little emphasis on these conditions, since in processes in which they are not adhered to a large percentage of coke breeze may be produced, with a corresponding diminution in the commercial value of the smokeless fuel.

When the coke is obtained in the form of robust lumps which will withstand transport it may be assumed that it possesses, at any rate in Great Britain, the same commercial value as that of household coal. From the experience we have gained, this product is an attractive fuel for anthracite stoves, open-fire grates and for certain types of kitchen stoves. It is easy to ignite, gives a cheerful and lasting fire, and if properly prepared is cleaner than coal, while it possesses the inestimable advantage that no black smoke is produced. In some respects it resembles anthracite, but yields a fire which is more genial.

Investigations have been carried out under the direction of the British Fuel Research Board which indicate that if the mass undergoing carbonization is too compact, considerable loss of the tar occurs. If, however, coal of greater size than $^1/_2$ in. is used the yield of oil is increased. In processes which do not aim at the production of a lump fuel the coal may be carbonized in a finely divided condition and be kept in motion either by means of a revolving retort, by plows, or by allowing it to enter a heated retort in a pulverized form. Such methods of treatment increase the yield of tar, while the solid product is suitable for use as pulverized fuel after further grinding; it may, on the other hand, be converted into briquets suitable for general industrial purposes.

It is of interest to examine for a moment the materials of which plants for low-temperature carbonization should be constructed. It would appear that for the production of a robust smokeless fuel a temperature of carbonization of at least 600 deg. cent. is required unless pressure be applied while the material is in the plastic state. In many suggested processes temperatures of 625 to 650 deg. cent. are used, and it is recognized that this is a critical temperature for the normal types of cast iron available in commerce. Should these temperatures be exceeded the rate of deterioration of the cast iron is excessive. The use of steels and semi-steels has been suggested,

but the problems of construction are by no means simple and the initial cost may be very great. Many of the difficulties do not arise in plants in which the aim is other than the production of lump smokeless fuel; in these cases the temperature may be maintained at such a level as to give a maximum yield of oil, which is lower than that usually required for the production of a coked solid product.

In the development of any process from the laboratory stage to that of commercial operation it appears to me that four distinct stages must be passed through:

1 The process must be worked out on the laboratory bench, using quantities which may be measured in grams.

2 An intermediate-scale unit is erected with a view to obtaining further designing data for a still larger unit. In this stage the plant will probably deal with several hundredweights per day.

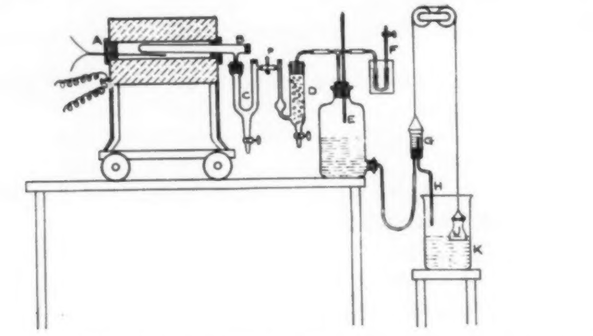


Fig. 1 Gray King Assay for the Low-Temperature Carbonization of Coal

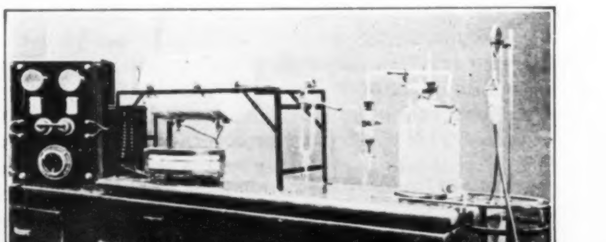


Fig. 2 Gray King Assay for the Low-Temperature Carbonization of Coal

3 A full-scale unit is erected and tried out. The size of this unit would depend upon the type of plant and might range between, say, 5 tons and 100 tons daily capacity.

4 A commercial battery consisting of several units similar to those which have been developed in stage 3 would be erected in a favorable locality so that the money-making capacity of the system could be tested by actual commercial audit.

It of course often happens that one or more of the stages are omitted, but this involves an element of gambling in which the odds are frequently heavily against the promoters. In the past much damage has been done to the cause of low-temperature carbonization by the omission of either stages 3 or 4, and plants of large size have been erected without a proper recognition of the factors involved, so that failure was almost inevitable. There are several processes of low-temperature carbonization in which the work is being carried out on sound lines. Most of these may be said to have reached the end of stage 2. One or two are approaching the end of stage 3. None have yet reached the end of stage 4 where they can produce audited figures showing actual profit made from a plant working under normal commercial conditions.

The stages may be illustrated very well by the work which has been carried out during the past seven years at the British Fuel Research Station. Figs. 1 and 2 show a method of low-temperature assay in which 20 grams of the coal to be used can be carbonized in a silica tube, the products, coke, tar, ammonia, and gas, being carefully measured. In this apparatus it is possible to determine the properties of a coal or a blend of coals with respect to low-temperature carbonization.

Fig. 3 gives an illustration of the intermediate-scale type of apparatus which comes under stage 2. The original battery consisted of nine horizontal steel retorts, each 9 ft. long, $2^1/_2$ ft. wide, and about 6 in. high. The coal is carbonized in trays, each tray being the full width of the retort and 3 in. deep. The vapors are led through a gas connection at the back of the retort, and a complete condensing system and recovery plant is installed.

Fig. 4 shows the plant now in operation. It consists of two simple cast-iron vertical retorts, each 21 ft. high, the internal dimensions being 7 in. by 6 ft. 6 in. at the top, tapering to 11 in. by 6 ft. 10 in. at the bottom. These are enclosed in a simple brick setting and heated by gas, either coal gas or blue water gas being used. Although producer gas would probably be used in practice, it is not used in the experimental retorts on account of the necessity for accurate measurement of the amount of heat supplied to the setting. It has been found that these retorts work excellently with a sized, non-swelling coal, giving good tar yields and a robust, easy-burning coke without an undue proportion of breeze. It has also been found that easy working and good yields can be obtained from a sized or screened coal of the swelling variety, but that if fine coal is charged to the retorts, or run-of-mine coal containing fine coal,

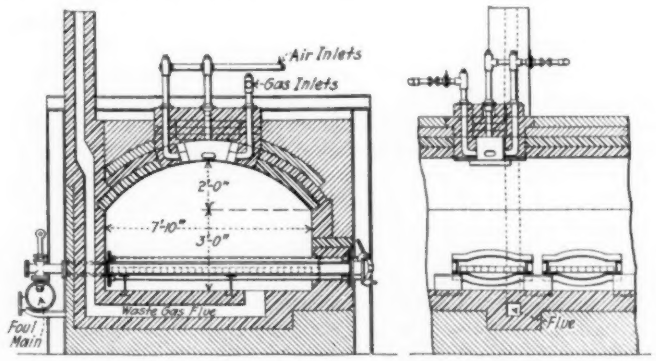


Fig. 3 Intermediate-Scale Apparatus for the Low-Temperature Carbonization of Coal. Horizontal Steel Retorts

the tar yield falls off considerably, and the throughput of the setting is reduced. The throughput of coal treated under the best conditions is 7 to 8 tons a day for the setting, and the temperature of the wall of the retort is kept as close as possible to 625 deg. cent. (1157 deg. fahr.), care being taken to prevent local overheating. The setting in question has been under heat since December, 1925. The method of working is to run the extractor for a few minutes at regular intervals of 1 or 2 hours, thus dropping the level of the coke in the retort, which is then filled up with coal, and left quiescent until the next charging period. Steam amounting to 10 to 20 per cent of the weight of coal is admitted to the base of the retorts.

It appears likely that this system is approaching the end of stage 3. When we are satisfied that that goal has been reached, arrangements will be made for a commercial battery to be installed under suitable conditions in order to carry its development to the end of stage 4.

Low-Temperature Coke

The study of the behavior of different coals carbonized at the temperatures usually associated with low-temperature carbonization, 600 to 700 deg. cent., has thrown much light on the influences which determine the physical structure and the chemical properties of the resulting smokeless fuel. The sponge-like structure results from the simultaneous melting and evolution of gas which takes place between 350 and 700 deg. cent. It may be accepted that the ultimate structure of the material is mainly determined by the treatment which it receives at this stage. It would be impossible within the limits of a single lecture to consider the characteristics of all varieties of coke, but the work would be incomplete without a short consideration of low-temperature coke.

The coherency of coke can be shown to depend largely upon the presence of certain substances which on carbonization act as ce-

menting materials to other constituents. If this binding material is in excess, foaming may occur. This may be prevented in various ways, such as by confining the coal and so rendering it impossible for it to expand, or by subjecting it to a preheating treatment or to oxidation, which destroys some of the binding material. One of the most direct and economical methods is to provide by blending with non-caking coal or coke a sufficient amount of inert matter which will absorb and so utilize the excess binder resulting from the swelling coal.

Low-Temperature Tar

The tar produced during the process of low-temperature carbonization differs essentially from that obtained when coal is heated to a high temperature. High-temperature tar contains a considerable proportion of benzene, toluene, xylene, and naphthalene compounds which are essential for the manufacture of dyes and explosives. This type of tar also yields a high percentage of pitch when it is distilled; the pitch is, however, a valuable product for many purposes, of which the most important is road making.

The above-mentioned chemical compounds are absent from low-temperature tar, while the amount of pitch formed on distillation is very much less than with high-temperature tars.

In view of these facts it is clear that new uses must be discovered for low-temperature tar and for the products which may be separated from it. The present trend of thought appears to be that its chief value will be as a fuel, although the large percentage of phenols it contains may find applications in the chemical industry.

Some divergence of opinion exists among chemists as to the temperature of carbonization at which tar possessing the most valuable qualities is obtained. There appears some reason to suppose that each type of plant may modify in some characteristic manner the composition of the tar produced from a particular coal, and each of the types of plant previously mentioned produces a different amount of oil from the coal. In order to examine this important question a detailed investigation was started some years ago to inquire into the various aspects of its application to British coals. The results of this investigation can here only be summarized. For details a paper by my associates Sinnatt, King, and Linnel, which will shortly be published in the Journal of the Society of Chemical Industry, can be consulted. In the investigation a typical British coal was carbonized at a series of temperatures ranging from 400 to 700 deg. cent. in 50-deg. intervals. Sufficient tar was obtained at each of the temperatures to permit detailed examination, and Table 2 contains a number of the chief values obtained.

TABLE 2 YIELDS OF PRODUCTS OBTAINED BY CARBONIZATION OF A MEDIUM CAKING COAL AT TEMPERATURES FROM 400 TO 700 DEG. CENT.

	Carbonizing temperature, deg. cent.						
	400	450	500	550	600	650	700
	Percentage by weight of coal						
Coke	88.2	83.75	80.50	77.00	75.00	73.00	71.00
Tar	3.9	5.62	7.06	8.00	7.60	6.90	6.24
Aqueous distillate	5.6	7.01	7.92	7.70	8.12	8.20	7.18
Gas	2.2	3.32	4.05	7.14	9.10	10.54	14.58
Loss	0.1	0.30	0.47	0.16	0.18	0.36	1.00
Water produced (net)	2.2	3.61	4.52	4.30	4.72	4.80	3.78
Gas, cu. ft. per 100 lb.	34.5	56.2	70.9	126.0	194.3	237.2	356.5
Coke (dry):							
Volatile matter	16.5	13.1	11.6	8.1	5.4	4.5	3.2
Tar (dry):							
Specific gravity at 15 deg. cent.	0.958	0.980	0.986	1.015	1.039	1.078	1.080
Gal. (Imp.) per ton (2240 lb.) of coal	9.1	12.8	16.0	17.65	16.4	14.35	12.9

Metallurgical Coke

During the last few years special attention has been paid to the technique of coke production with the object of obtaining a clearer insight into the conditions prevailing in a coke oven during normal operation. Foxwell[11] investigated the duration of the plastic state, the path of travel of the gases in an oven, and their influence upon the products of carbonization. He determined the resistance to the passage of the gas of the coal before carbonization, when the plastic state occurred, and after coking. From his results he was able to suggest that in a coke oven, owing to the relatively high resistance of the plastic mass, the gases first evolved tend to pass inward to the center of the oven. The path taken by the gases may be controlled to some extent by the size and coking properties of the coal used. The amount of decomposition of the gaseous products will depend on their path of travel, and thus the yield of products can be varied by an alteration in the conditions of working. Foxwell also investigated the "plastic curves," obtained with coking and non-coking coals, work which is of significance in relation to coal blending. This aspect of the subject has been studied by Forster,[12] Sensicle,[13] and Thau,[14] with results which lead to similar conclusions. These investigations are of considerable interest, since a knowledge of the conditions prevailing during the coking process is a necessary preliminary to the design of efficient coke ovens. Attention is being focused upon this point, and interesting developments are taking place in which the width of the oven is decreased. The claims made for such a modified design are that (*a*) shorter periods can be used with subsequent increase in the output of the ovens, (*b*) that the coke is more uniform, and (*c*) that coke suitable for metallurgical purposes can be made from coals hitherto considered unsuitable.

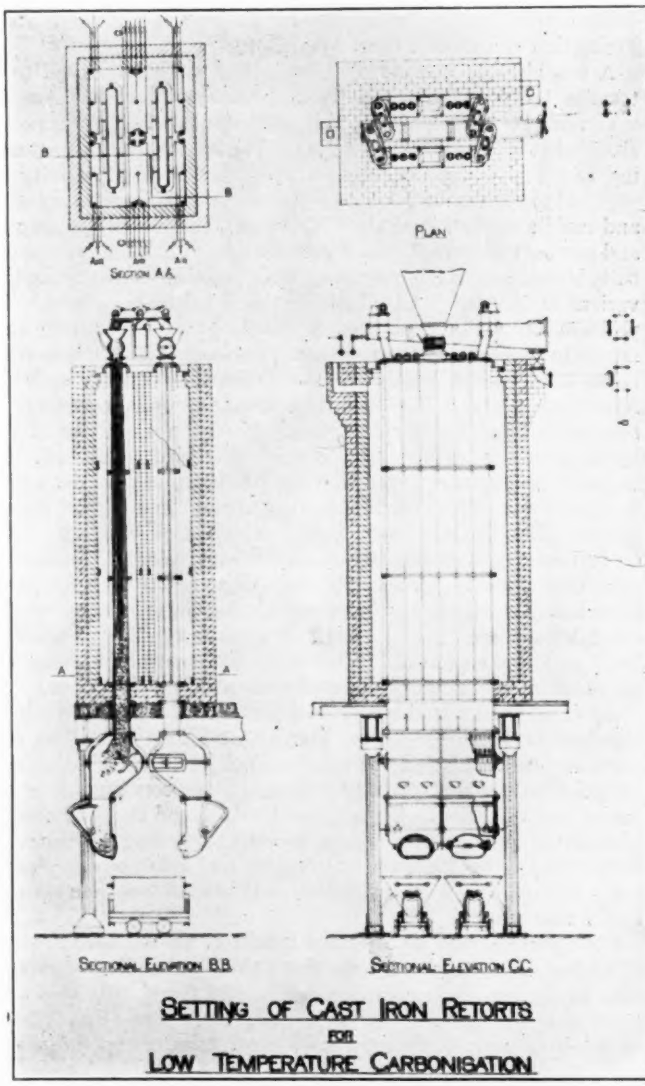


Fig. 4 Low-Temperature Carbonization. Experimental Vertical Cast-Iron Retorts with an Approximate Daily Capacity of 8 Tons

A most fascinating but difficult problem is encountered in the study of the properties of coke. What properties are really required in blast-furnace coke, and what is their order of relative importance? Is it desirable that a coke should possess high reactivity, or is this property relatively unimportant when compared

[11] G. E. Foxwell, *Fuel*, vol. 3 (1924), pp. 122–128, 174–179, 227–235, 276–283.

[12] W. Forster, *Gas World*, vol. 82 (1925), C. S. 48–52.

[13] L. H. Sensicle, *Gas World*, vol. 82 (1925), C. S. 61–63.

[14] A. Thau, *Gas World*, vol. 82 (1925), C. S. 59–60; *Fuel*, vol. 4 (1925), pp. 169–175.

with such factors as the percentage of ash present or the hardness of the coke? These problems have been attacked in America by Sherman, Perrott, Kinney, and Fieldner,[15] who made use of an experimental producer with arrangements whereby samples of gas could be drawn from various levels in the fuel bed and in the stack. Their results seem to indicate that the nature of the combustions at the tuyeres is influenced to only a minor degree by the chemical properties of the coke. This broad conclusion, which suggests that the capacity of the coke to withstand shock and abrasion is more important than its chemical properties, has, however, not yet been accepted universally. Investigations of a similar character are being carried out in England under the auspices of the National Federation of Iron and Steel Manufacturers.

A considerable number of investigators have attempted to determine the so-called reactivity and combustibility of cokes, but with our present knowledge it is not even possible to define precisely what is meant by these terms. The investigators are attempting to establish relationships between the chemical activity and physical properties of coke. Factors such as the percentage of ash and mobile matter, the nature of the ash, the porosity, adsorption, and mechanical strength have been examined, but the present difficulty is experienced not only in devising methods for measuring these various factors but in distinguishing their individual effects. This problem has not been sufficiently elucidated for any definite statements to be made at the moment. One aspect of the question is being investigated jointly by the Federation of Iron and Steel Manufacturers and the Fuel Research Division. A method has been elaborated for the determination of the reactivity of coke by its action on carbon dioxide under standard conditions. The important fact has emerged that the reactivity of coke determined in this way may vary during its exposure to the action of the carbon dioxide. Certain types of coke exhibit high reactivity which on further exposure decreases to a constant value. Metallurgical coke exhibits only a relatively low initial reactivity, but at the same time a relatively small decrease during the treatment, whereas cokes with a high initial reactivity sometimes show a relatively large and rapid decrease. This observation is one of very considerable interest and is being explored in various directions.

An entirely new field has recently been opened up by the investigations of Lessing,[16] Cobb, Marson, and Pexton.[17] The early work of Lessing carried out for the Fuel Research Division drew attention to the part played by the inorganic constituents of coal during carbonization. Lessing and Banks found that the addition of small amounts of certain inorganic substances had a profound influence upon the structure and amount of coke produced when sugar and cellulose were carbonized. This work was then extended to the case of coal.

Cobb and Marson investigated the effect on the coke produced of adding silica, calcium oxide, iron oxide, and sodium carbonate, etc., to the coal before carbonization, and found that this treatment increased the reactivity of the coke to steam and carbon dioxide to a remarkable extent. In one series of experiments the amount of steam decomposed under certain standard conditions was 61 per cent with coke from the untreated coal, 82 per cent when calcium oxide had been added, 91 per cent with iron oxide, and 98 per cent with sodium carbonate. These results indicate avenues of investigation which may have a profound influence not only upon the process of low-temperature carbonization, but also upon the coke oven and the iron and steel industries.

In an earlier part of my lecture dealing with the preparation of coal for the market, the importance of obtaining coal with a low ash content was developed; it would appear, however, that if the properties of coke may be modified by the addition of inorganic substances, the process of preparing coal for the market may possibly in the future involve the addition of critical amounts of certain inorganic compounds to the coal as well as the removal of other inorganic compounds. In such conditions the methods of dry cleaning would not be so suitable as those in which water is used. In some preliminary experiments carried out at H. M. Fuel Research Station it has been found that the reactivity of coke may be varied by altering the conditions of carbonization; and an example of this was observed in the coke produced during the carbonization of sized (nut) coal at high setting temperatures when the throughput of a particular plant was double the normal capacity of the plant. The coke produced was found to be more readily combustible than the normal coke.

The Production of Free-Burning Coke by High-Temperature Methods

The plant used is the setting of four Glover-West retorts originally installed at the Fuel Research Station and is illustrated in Fig. 5. The dimensions of the retorts are 33 in. by 10 in. at the top by 21 ft. high. There are seven heating chambers and two waste-gas circulating chambers.

The amount of treated coal (Mitchell Main Gas Nuts, South Yorks) has been increased from the rated amount of 2.5 (long) tons per retort per day to 7.0 (long) tons, the average temperatures of the setting being maintained at the original value, viz., 1260 deg. cent. No advance on the throughput of 7.0 tons has yet been achieved, as even so a fairly high proportion of partially carbonized coal is extracted with the coke.

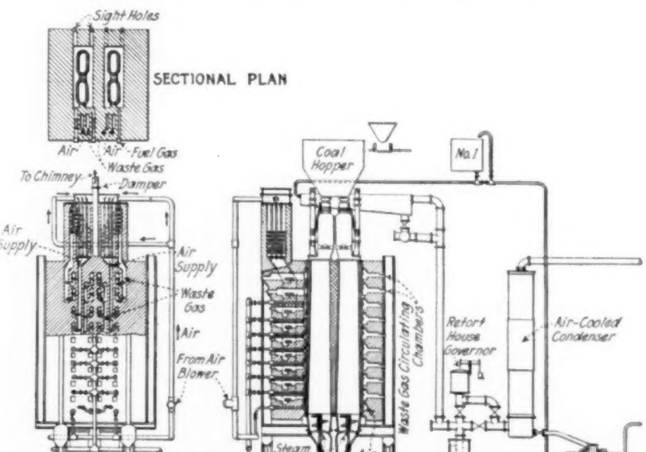


Fig. 5 Glover-West Vertical Retorts at H. M. Fuel Research Station, East Greenwich, England. Normal Throughput per Retort, 2.5 Long Tons

The coke is of more open texture than that normally produced, and the average percentage of volatile matter is higher. When the coke is screened, however, the breeze (less than $^7/_8$ in.) is found to contain all the high-volatile coke, and the lump coke contains little more volatile matter than in normal practice.

The ease of ignition and combustibility of the coke have been compared and it has been found that the "new" coke burns more freely than the old and is readily ignited in an ordinary domestic grate by means of seven 7-in. by $^1/_2$-in. by $^1/_2$-in. chips of yellow deal and one full sheet of a daily newspaper. It also gives a brighter fire, and when allowed to burn out does not leave so much unburned fuel.

It is, however, not so free-burning as smokeless fuel produced by carbonization at low temperatures (about 600 deg. cent.), and experiments are being continued to determine whether this standard may not be achieved.

The immediate interest of the investigation lies in the successful working of the plant at more than 100 per cent increase on the rated throughput and the production of a relatively free-burning coke in gas retorts of existing design.

Table 3 shows the comparative yields with throughputs of 2.5 and 5.0 long tons per retort per day.

[15] Sherman & Kinney, *Fuel*, 1926, pp. 98–105.
Perrott & Kinney, Trans. A.I.M.E., vol. 69 (1923), pp. 543.
Perrott & Fieldner, Am. Soc. Testing Materials, June, 1923.
Fieldner, *Chem. & Met. Eng.*, vol. 29 (1923), pp. 1052–1057.

[16] Lessing, *Fuel*, 1926, pp. 117–124; *Jl. Soc. Chem. Indus.*, 1925, pp. 345T.
Lessing & Banks, *Jl. Chem. Soc.*, vol. 125 (1924), pp. 2344–2356.

[17] Pexton & Cobb, *Gas Jl.*, vol. 167 (1924), pp. 161–169; *Gas World*, 1924, pp. 675–678.
Marson & Cobb, *Gas Jl.*, vol. 171 (1925), pp. 39–46.

Attention is directed to the increase in the thermal yield of gas per retort per day (40.5 per cent), the decrease in the thermal yield of gas per ton of coal (29.9 per cent), the increase in the calorific value of the gas (100 B.t.u.), the increase in the yield of

TABLE 3 ILLUSTRATION OF PRELIMINARY EXPERIMENTS ON THE PRODUCTION OF FREE-BURNING COKE IN HIGH-TEMPERATURE RETORTS

(Coal used: Mitchell Main Gas Nuts)

Throughput		
Tons (2240 lb.) per retort per day	2.50	5.01
Moisture in coal as charged, per cent	0.7	2.3
Duration of test, hours	72.0	96.0
Coal		
Total carbonized, tons (2240 lb.)	30.0	80.3
Steam		
Rate, lb. per hr	187	473
As per cent of coal	20.05	25.24
Coke		
Over 7/8 in., cwt	12.04	11.6
Volatile matter, per cent	2.42	3.0
Through 7/8 in., cwt	1.23	2.9
Volatile matter, per cent	...	12.8
Gas		
Yield per retort per day, cu. ft	52,010	60,170
therms	244.0	342.9
Yield per ton (2240 lb.) of coal, cu. ft	20,810	12,010
therms	97.6	68.44
Calorific value, B.t.u. per cu. ft	469	570
Specific gravity (air = 1)	0.424	0.410
Tar (dry)		
Yield per ton (2240 lb.) of coal, gal. (vol. of 10 lb. of water)	13.35	15.80
Specific gravity at 15 deg. cent	1.10	1.088
Ammonium Sulphate		
Yield per ton (2240 lb.) of coal, lb	22.2	25.45
Carbonizing Temperature		
Mean of combustion chambers, deg. cent	1,260	1,260
Fuel Gas		
Fuel gas per hour, cu. ft	6,010	7,240
therms	17.2	21.4
Fuel gas per therm of coal gas made, therms	0.42	0.37

NOTE: 1 therm = 100,000 B.t.u.

tar (18.3 per cent), the decrease in the yield of lump coke over 7/8 in. (3.7 per cent), and the increase in the fuel expenditure (24.4 per cent). The fuel expenditure per therm (100,000 B.t.u.) of gas produced is lower by 11.9 per cent.

A considerable amount of work is also being carried out at the present time both in the United States and in Europe on the variations in combustibility which may be effected by blending different varieties of coal and also by blending coal with coke breeze under both high- and low-temperature conditions.

Pulverized Coal and the Structure of Cenospheres

In considering the problems of the burning of coal in the pulverized form and of the process for the carbonization of coal in the form of fine particles, it may be interesting to review the investigations which have been carried out by Sinnatt and others on the production of "cenospheres." Sinnatt,[18] who commenced to work on these lines in 1917, has shown that when particles of caking coal are brought into an inert atmosphere at temperatures exceeding about 500 deg. cent., the carbonization of the coal is accompanied by the production of minute hollow spheres, which he has termed "cenospheres." Using particles of coal 0.3 mm. in diameter, and exposing them (under suitable conditions) to a temperature of 600 deg. cent., cenospheres of about 0.5 mm. diameter are formed, while if the temperature be 800 deg. cent., the diameter is about 0.7 mm. and the volumes of the cenospheres are about eight times those of the original coal particles, the specific gravity of the cenospheres being 0.3.

Cenospheres are found, under the microscope, to consist of two main structures: a practically opaque skeleton or framework, to which the name "lattice" has been given, and a thin, transparent, brownish film filling the interspaces in the lattice, forming what have been termed "windows." (Figs. 6 and 7.) It has further been observed that in the window portions of the cenospheres there are minute structures, appearing as specks (Fig. 8), for the formation of which no adequate explanation has yet been offered. Sinnatt has estimated that these number in the neighborhood of 10,000 upon the face of a single cenosphere of which the area is of the order of 1 sq. mm.

The coke produced appears to be eminently suitable for use in powdered-fuel plants since it presents an enormous surface upon which combustion can take place. The bubbles or cenospheres are extremely delicate and are easily crushed to a much greater degree of fineness should this prove necessary.

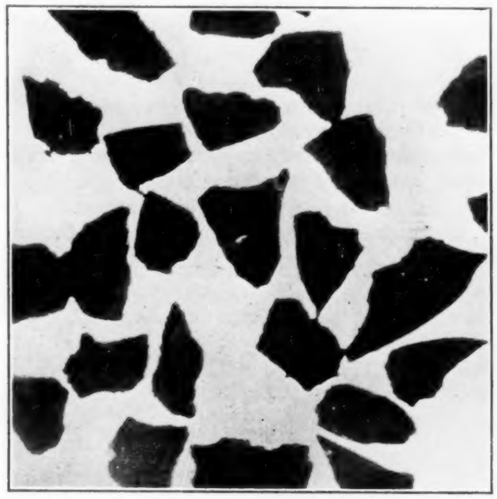


FIG. 6 ARLEY COAL. "CLARAIN" CONSTITUENT GROUND TO PASS THROUGH 60-MESH AND TO REMAIN UPON 90-MESH SIEVE. MAGNIFICATION × 45

FIG. 7 "CENOSPHERES" FORMED FROM "CLARAIN" OF ARLEY COAL. MAGNIFICATION × 45

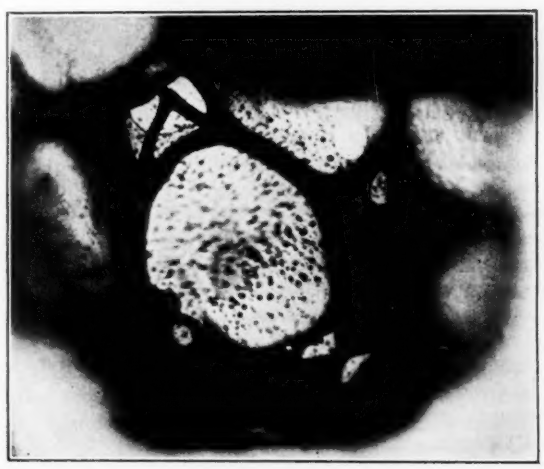


FIG. 8 "CENOSPHERES" FROM "CLARAIN" OF ARLEY COAL SHOWING SPECKS ON WINDOW. MAGNIFICATION ×150

[18] Newall and Sinnatt, Carbonization of Coal in the Form of Fine Particles, *Fuel in Science and Practice*, vol. 3 (1924), p. 424.

The experiments upon the cenospheres have been carried forward, and it has been found that when a particle of coking coal burns it probably passes through three stages: first of all a cenosphere is formed, then the windows burn, and finally the lattice. The truth of this observation is confirmed to some extent by the fact that cenospheres have been found in considerable quantities in the dust emitted from cement works, a Channel steamer, a locomotive, an ordinary boiler plant, and a pulverized-fuel plant.

It is clear that these observations are of interest to those engaged upon the study of any problems in which coal dust is being burned, and are of some importance in relation to the explosibility of coal dust in mines and in the study of caking phenomena. It should be remarked that cenospheres are formed only from the clarain and vitrain portions of coals which possess caking properties, and that non-caking coals, durain and fusain, do not form cenospheres.

Fig. 9 Patart Process for the Synthesis of Alcohols from Water Gas. The Water-Gas Generator and Gas Holder

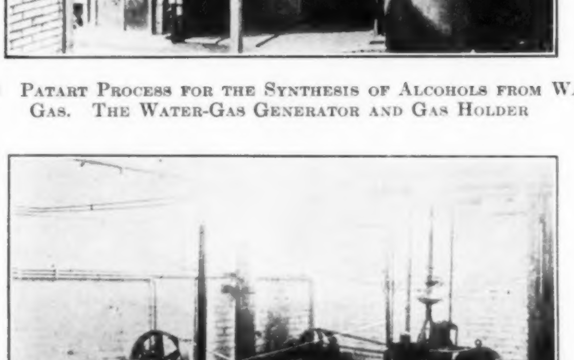


Fig. 10 Patart Process. The Compressor (300 Atmospheres) and Circulating Pump

The practical application of this work can take two forms, both of which are the subject of large-scale experimentation at the present time, with the object of extracting oils from powdered coal before it is burned in furnaces. The work of McEwen in London and of Runge in the United States is well known and forms the basis of a 200-ton-per-day unit at present being tried out in Milwaukee.[19] In this application the fine coal is carbonized by showering it through an upward current of hot inert gas so that the particles are heated to the carbonizing temperature by convection. The gases given off are of course diluted by the heating gases. The results of the Milwaukee experiments are awaited with great interest by technologists on both sides of the Atlantic.

In the second of the two applications mentioned above the coal is showered through a retort whose walls are maintained at the desired temperature so that carbonization is effected by the combined action of radiation and of convection. At the present time development in this direction is being undertaken by Prof. A. N. White at the University of Michigan and also by Sinnatt at the Fuel Research Station in England. For details of the work of Professor White, reference should be made to the comprehensive paper read by him at the recent Conference on Bituminous Coal held at Pittsburgh.[20] The experiments of Sinnatt take the form of showering the coal through either cast iron or silica vertical retorts 21 ft. high by about $3^1/_2$ sq. ft. sectional area which can be heated in zones of varying widths.

Both methods of carbonizing crushed coal are attractive since they present the possibility of obtaining a large throughput from a plant of simple design, which is essential in any system for the precarbonization of coal before furnace firing.

Production of Oil from Coal by Methods Other than Carbonization

At the present time perhaps the most striking instance of the relation between science and engineering is afforded by those processes by which the coal substance is transformed into liquid fuels by the methods of synthesis or hydrogenation. These are of particular interest to the present gathering since they may possibly supply or supplement in the future materials which at the present time can only be obtained from natural oil wells. They also require in their development the art of the mechanical engineer in the construction of types of apparatus which will deal with extreme pressures accompanied by elevated temperatures.

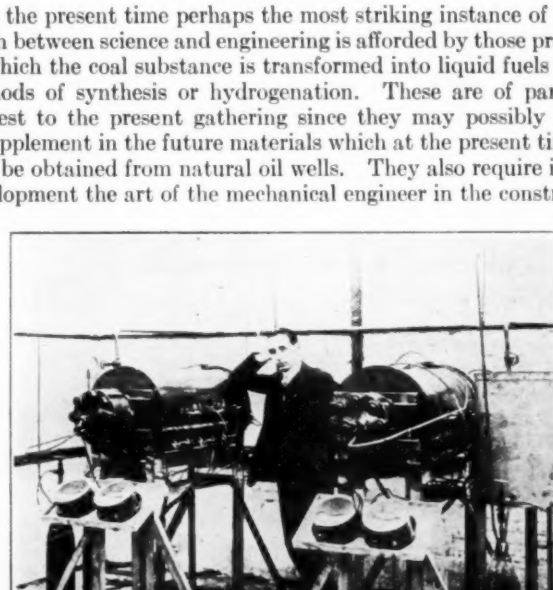


Fig. 11 Patart Process. The High-Pressure Bombs

Two distinctly different principles offer alternative methods of solving the problem.

Synthetic Fuels from Carbon Monoxide and Hydrogen. In the first of these, described initially by the Badische-Anilin-und-Soda-fabrik and followed up and extended by Franz Fischer in Germany and Patart and Audibert in France, the complicated molecules of the coal substance are first broken down into carbon monoxide and hydrogen by the action of steam upon the red-hot carbonaceous matter according to the water-gas reaction

$$C + H_2O \rightleftharpoons CO + H_2$$

The above workers have shown that it is possible to effect a recombination of these molecules with or without added hydrogen by the action of heat in the presence of a catalyst. The method has been shown to possess a considerable degree of elasticity, and by adjusting the conditions of pressure and temperature the products may be modified to suit the particular end in view. These products range from oxygen-containing compounds such as methyl alcohol CH_3OH, ethyl alcohol C_2H_5OH, to liquid and solid hydrocarbons—for instance, of the paraffin series. The introduction of cellulose lacquers has involved large requirements of methyl alcohol, and since this material commands a high price in comparison with some of the other products which only possess a fuel value, the efforts of the earlier workers were directed to the production of this member of the alcohol family. The process is now being worked on a large scale.

In the method due to General Patart, water gas made from coal

[19] The McEwen-Runge Process for the Low-Temperature Carbonization of Coal. Dr. Walter Runge, International Conference on Bituminous Coal, 1926, Carnegie Institute of Technology, Pittsburgh, Pa.

[20] The Instantaneous Carbonization of Crushed Coal, Alfred H. White. International Conference on Bituminous Coal, 1926, Carnegie Institute of Technology, Pittsburgh, Pa.

or coke is passed through water scrubbers and the ordinary gas-works type of iron oxide-sulphur purification apparatus to a gas holder. From this it is compressed into the catalyst-tube system by a compressor capable of exerting a pressure of 300 atmospheres. The catalyst tubes are heated electrically and the gases passing through them are maintained at temperatures of 380 to 450 deg. cent. Patart states that if methyl alcohol is required a temperature of 380 deg. cent. is the most suitable, while if the higher alcohols which form good motor fuels are required a temperature of 450 deg. is necessary. A circulating pump in the closed circuit maintains the flow through the catalyst tube and recirculates through charcoal filters that proportion of the gas which has escaped conversion. The circulating pump is geared directly to the dynamo which supplies the electrical energy necessary for heating, so that in the case of a stoppage of the circulating pump the heat supply is automatically cut off.

The arrangement adopted by Patart for heating his catalyst tube is of great interest. It is obviously undesirable to pass the heat through the thick walls of the high-pressure chamber, fairly steep temperature gradients would be required, and in order to maintain the correct temperature of the catalyst the outside of the bomb wall would require to be held at 500 deg. cent., or even higher. In order to overcome this the bomb is heated internally by electrical means. The gas mixture first passes between the pre sure wall of the bomb and the catalyst tube; it then passes through a heater consisting of carbon granules which is contained within the end of the catalyst tube and insulated from it by means of an alundum tube. On leaving this heater the gas passes over the catalyst and through the condenser to the high-pressure receiver, from which the product may be withdrawn from time to time.

The speaker is indebted to General Patart for the illustrations (Figs. 9–11) of a semi-industrial-scale plant of a capacity of 150–200 kg. per hour now in operation in the Etablissements Poulenc Frères at Vitry-sur-Seine.

The Franz Fischer process for the manufacture of synthetic fuels from water gas differs from the alcohol synthesis described above in that Fischer uses atmospheric pressures and produces the liquid and solid hydrocarbons of the petroleum series. Oxygen-containing products are absent. A yield of 100 grams of solid, liquid, and easily liquefiable hydrocarbons is claimed from each cubic meter of water gas.

In all industrial chemical processes involving the action of catalysts, precautions have to be taken to avoid the poisoning of the catalysts by various bodies which may be present as impurities in the gases used. In the Badische process for the manufacture of methanol such difficulties have been successfully overcome. One such deleterious agent is the sulphur usually present in industrial water gas. In certain processes it is necessary that exceedingly pure mixtures should be used. In the Patart process it is claimed that purification need not be carried further than is required for towns' purposes, while Fischer states that he has "solved the problem of the purification of technical gases in a simple manner, and the durability and possibility of regeneration of the contacts leave nothing more to be wished.[21]

The recent papers which General Patart and Professor Fischer have delivered before the International Conference on Bituminous Coal at Pittsburgh on the processes associated with their names make it unnecessary to deal in greater detail with the production of synthetic fuels from mixtures of carbon monoxide and hydrogen. It is not clear, however, at the present stage of these processes how far the thermal losses associated with them will militate against their commercial prospects in the production of motor spirit from coal. It would appear that coal must be converted into coke, which must then be transformed into water gas, which must again be treated with a catalyst. The thermal losses involved are not inconsiderable, and it will be necessary to await the results of working a full-sized-unit plant before the technical and commercial outlook can be clarified. The development of the processes may be expected to include (*a*) the low- or high-temperature carbonization of the coal, (*b*) the conversion of the low- or high-temperature coke into water gas, and (*c*) the conversion of the gas with or without added hydrogen into liquid fuel.

[21] The Synthesis of Petroleum, by Franz Fischer. Carnegie Institute of Technology, Pittsburgh, Pa.

Hydrogenation of Coal. Another process for the manufacture of oils and gasoline from coal is the process of hydrogenation carried out by Dr. Bergius at Mannheim-Rheinau. This differs from that described above in that hydrogen is directly added to coal by the action of heat and high pressure.

Table 4 due to Butterfield shows very approximately the ultimate chemical composition of various carbonaceous materials, from which

TABLE 4 ULTIMATE CHEMICAL COMPOSITION OF VARIOUS CARBONACEOUS MATERIALS

	Carbon	Hydrogen	Oxygen	Nitrogen	Sulphur	Ash
Cellulose	44.4	6.2	49.4	...	...	...
Dry wood (average)	48.5	6.0	43.5	0.5	...	1.5
Dry peat	58.0	6.3	30.8	0.9	Trace	4.0
Lignite	67.0	5.1	19.5	1.1	1.0	6.3
Coal	77.0	5.0	7.0	1.5	1.5	8.0
Anthracite	90.0	2.5	2.5	0.5	0.5	4.0

it will be seen that, for instance, the ratio of carbon to hydrogen in coal is from 15 to 16, while that of lignite is about 13. The carbon-hydrogen ratio of oil would be of the order of 8 to 1. It follows, therefore, that one essential of a complete transfer of coal to oil, if such were possible, is the increasing of the hydrogen quantity

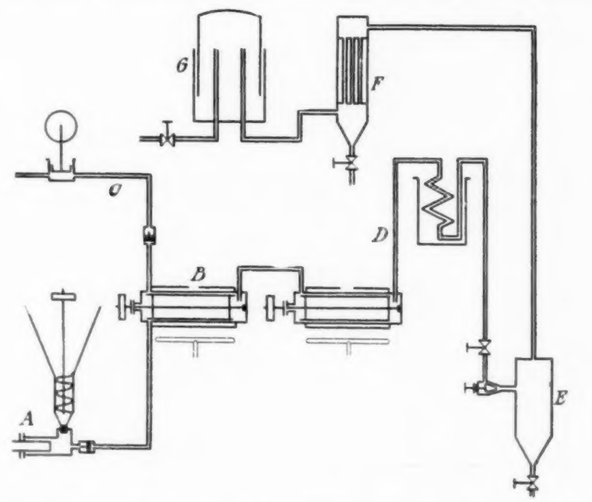


FIG. 12 BERGIUS PROCESS FOR THE "HYDROGENATION" OF COAL. DIAGRAM OF CONTINUOUS PLANT

by about 100 per cent, while in the case of lignite the hydrogen would have to be increased by about 60 per cent. These figures would of course be modified considerably in either direction with the various varieties of bituminous coals and lignites.

Table 5 gives the classification of coal adopted by the United States Geological Survey.

TABLE 5 U.S. GEOLOGICAL SURVEY'S CLASSIFICATION OF COAL

Group	Description	Ratio C:H
A	Graphite	∞ to (?)
B	Anthracite	(?) to 30 (?)
C		(?) 30 to 26 (?)
D	Semi-anthracitic	(?) 26 to 23 (?)
E	Semi-bituminous	(?) 23 to 20
F	Bituminous	20 to 17
G		17 to 14.4
H		14.4 to 12.5
I		12.5 to 11.2
J	Lignite	11.2 to 9.3 (?)
K	Peat	(?) 9.3 to (?)
L	Wood	7.2

The object of the Bergius process is then to adjust the carbon-hydrogen ratio of bituminous coals and lignites to about that found in natural oil, and to cause the molecules to split up and take up hydrogen in order to form a material similar to oil.

During the past few years the author has watched closely the work of Bergius at Mannheim, and laboratory work on the process has taken a place in the program of H. M. Fuel Research Station at East Greenwich, England. An intermediate-scale continuous plant similar to that with which Bergius has recently been working is in course of erection at that station, and the process will now be described with particular reference to that plant.

The coal is prepared for treatment by mixing it with a small quantity of alkaline iron oxide (luxmasse) and suitable oil or tar, which is usually a certain fraction of the Berginized product obtained from previous runs. This mixture in the form of a thick

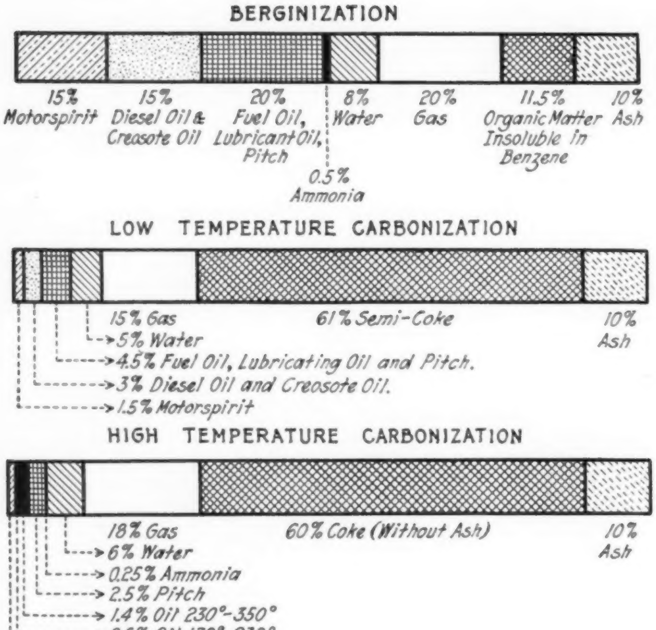


FIG. 13 BERGIUS PROCESS. COMPARISON OF YIELDS WITH THOSE ATTAINED BY LOW- AND HIGH-TEMPERATURE CARBONIZATION, RESPECTIVELY

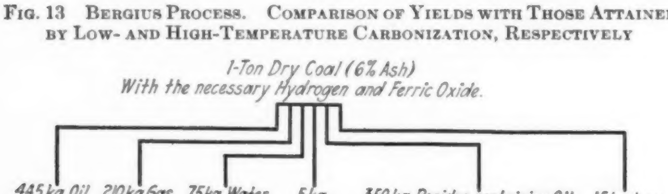


FIG. 14 BERGIUS PROCESS. YIELDS OF VARIOUS PRODUCTS FROM A SUITABLE GAS COAL

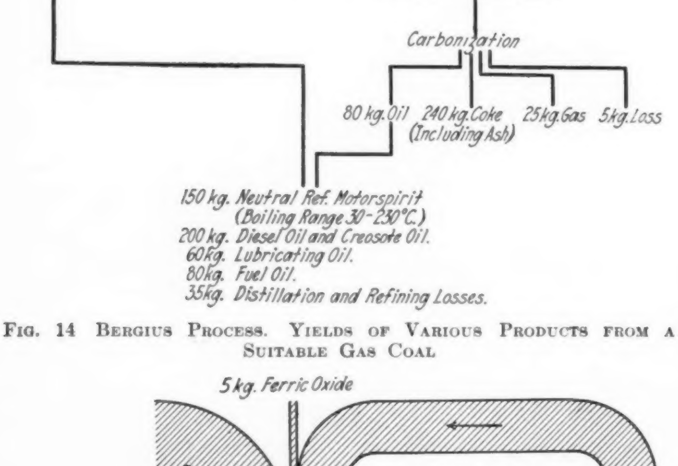


FIG. 15 BERGIUS PROCESS. DIAGRAM SHOWING SELF-CONTAINED CONTINUOUS OPERATION, THE GAS MADE BEING CRACKED SO AS TO SUPPLY THE NECESSARY HYDROGEN FOR THE PROCESS

paste is forced by a worm into the cylinder of the paste pump (*A*) (Fig. 12) during the outgoing stroke of this machine. On the ingoing stroke the paste is forced into the first reaction bomb *B* to which hydrogen under a pressure of about 180–200 atmospheres is also pumped through the pipe *C*. While in the bombs, of which three are now used in series, the mixture is agitated by means of paddles. A lead bath heated by gas surrounds the bomb so that the temperature (about 400 deg. cent.) can be very accurately maintained. In the first chamber the mixture of coal oil and hydrogen is heated to the reaction temperature, while in the two following bombs the temperature is held constant. On leaving the last bomb the "Berginized" product and gas are first cooled in condenser *D* and then allowed to separate in the separator *E*. From *E* the gas is taken through condenser *F* to the gas holder *G*.

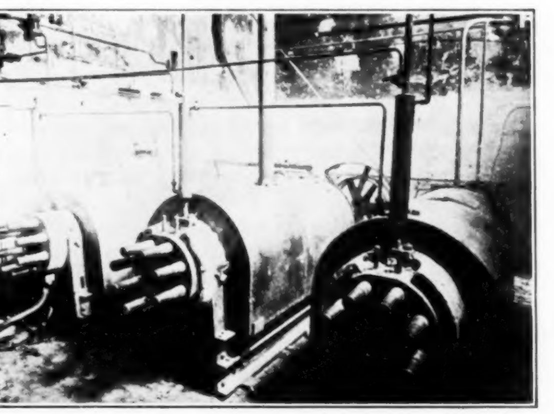


FIG. 16 THE BERGIUS PROCESS. HIGH-PRESSURE BOMBS OF INTERMEDIATE-SCALE CONTINUOUS PLANT

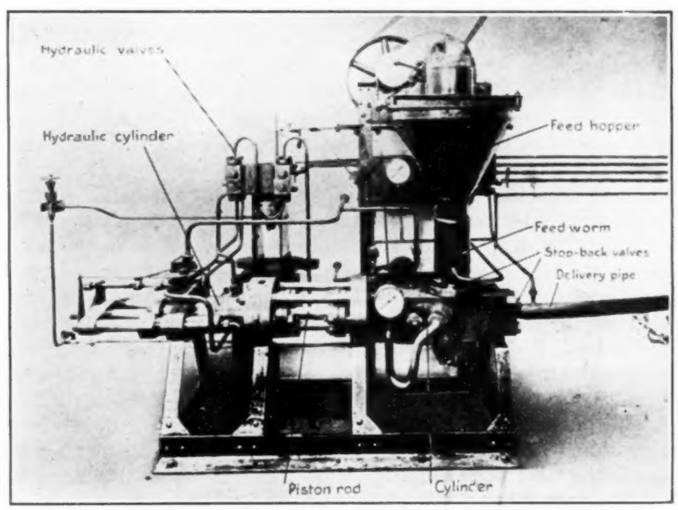


FIG. 17 THE BERGIUS PROCESS. PRESS FOR FORCING COAL AND OIL PASTE INTO THE HIGH-PRESSURE SYSTEM

The product removed from the plant is a relatively mobile oil, and the rough balance sheet of the process shows that 50 per cent of the coal is transformed into oil, 20 per cent into gas, and about 15 per cent remains as partially converted material. The hydrogen absorbed is about 6–7 per cent of the weight of the coal. The oil produced contains cyclic, aliphatic, and aromatic hydrocarbons, phenols, and a small proportion of acids and bases. On distillation something like twenty to twenty-five per cent of the oil remains as pitch. The engineering aspects of this process are especially fascinating since not only are metals required suitable for exposure to high temperatures, but they must also be capable of withstanding high pressures. It is clear that units of large capacity will be needed if the process is to have a commercial success, and this will also involve the production of large volumes of hydrogen.

In Fig. 14 are shown the yields of various fractions claimed by Dr. Bergius, while Fig. 13 gives a comparison of these yields with those obtained by processes of high-temperature and low-tem-

perature carbonization. It should be noted, however, that additional coal over the one ton actually worked upon will have to be supplied in order to produce the necessary powder for compression, and for the hydrogen. Fig. 15, however, shows how Bergius proposes where necessary to obtain the hydrogen by a process of cracking the residual gas.

A large-scale unit, it is understood, is now in course of erection for the German dyestuff group for the treatment of lignite and another in the Ruhr under the auspices of the Gesellschaft für Teerverwertung. The working results of these plants will be awaited with the keenest interest.

It is understood that in the large-scale working Dr. Bergius intends to use nitrogen as the heating vehicle. The cylindrical reaction chamber will have thin walls through which heat can be conducted with facility, and the nitrogen will be circulated under about 200 atmospheres pressure through the annular space between the reaction chamber and the thick walls of the containing bomb. The design of the large-scale plant bristles with ingenious mechanical devices that have been installed in order to overcome the great engineering difficulties met with. Fig. 16 shows the bombs in which the reaction is effected, while a photograph of the interesting paste press is given in Fig. 17.

Furnace Design

It is well known that the efficiency of industrial furnaces is generally very low, and the importance of a systematic study of reheating, forge, annealing, and all classes of furnaces has of late repeatedly been urged, both in the interests of fuel conservation and industrial prosperity.

The conditions governing the efficient combustion of fuel are now well understood, and if proper control is effected the thermal loss in unburned products need not be considerable either with solid, liquid, or gaseous fuel. The real problem in furnace work is the successful application of the heat generated to the purposes in hand. This involves an understanding of the fundamental physical principles underlying the mode of heat transfer from the hot gases flowing through a furnace to the charge, whether directly by radiation and convection, or indirectly by radiation from the heated walls and roof. The effective utilization of the sensible heat of the flue gases for the preheating either of the charge or of the air for combustion is of course also a fundamental condition of high furnace efficiency.

The work of Groume-Grjimailo on the flow of gases in furnaces has recently attracted considerable attention, since it represents a definite attempt to analyze the movement of the gases with a view to applying the knowledge gained to the more scientific design of furnaces. The results can of course represent at best only the general tendencies of the gaseous flow, and are not capable of yielding exact numerical information; but their application to furnace design has been shown to effect considerable practical improvement.

The problem of heat transfer inside a furnace, however, is very complex, and the important part played by radiation in the heating of the charge cannot be left out of account.

The remarkable success which has attended the application to airplane design of models based on Lord Rayleigh's principle of similarity suggests a further possible application to problems of heat transfer. The principle can be extended to considerations of heat transmission, but the conditions which it lays down for true similarity between model and full scale may be very difficult of practical realization if not impossible. The method offers interesting possibilities as a means of obtaining from determinations on a model, quantitative results applicable to full-scale furnaces.

Conclusion

The underlying idea of the Thurston Lecture must often render it impossible to arrive at definite conclusions regarding the various subjects dealt with. In the present case the speaker has attempted to point out how scientific research is at present engaged on many problems which, if successful solutions are found, will come within the purview of the mechanical engineer. Their commercial exploitation will often depend on circumstances, local or otherwise, beyond the control both of scientists and engineers, and time only can tell which, if any, of the processes dealt with in the present lecture will survive "to the use and convenience of man."

Low-Temperature Carbonization of Bituminous Coals of the Mid-Continental Type

THE first serious studies of fuel problems in America were made in the year 1826. The salient feature of these earlier studies on coal is the fact that they were of a simple character and were concerned almost entirely with questions of relative value. They were the direct reflection of the industrial needs of the time. The power engineer wanted to know the input and output of his plant. His needs were few and simple and could be stated in terms of ash, water, combustible, and heat units. The gas engineer was equally modest and would include perhaps one or two additional factors such as the number of cubic feet of gas per pound of coal, and the percentage yield of the coke produced.

Now what is the forecast for the new one hundred years upon which we are just entering? First and foremost we seem suddenly to have discovered that the old methods of proximate or ultimate analysis, while they might serve a few specific industrial needs in the past, were utterly lacking as a source of information to any one seeking a deeper insight into the possibilities of this very complex material. As a result there has already been opened up a new era in coal investigation which will certainly characterize the transition which this conference has the peculiar honor of emphasizing—an era in which we shall be primarily interested in the fundamental topics already coming into prominence in connection with studies on coal, such as composition, reactivity, solvent analysis, thermal decomposition, structural modification, and synthetic expansion, into fields that are fascinating in their possibilities and doubtless as bewildering as they are inviting. All of which emphasizes the fact that progress in fuel research must be based on very different factors from those which were sufficient in the preliminary stages.

The studies on low-temperature carbonization at the University of Illinois were begun early in the year 1902. It will be impossible in this brief reference to go into any of the details which have characterized this long-time study. The problem stated in general terms has been this: How can a thermal decomposition be brought about throughout a mass of coal which is, say, 14 inches in cross-section, and which is to be subjected at no point to a temperature in excess of 750 or 800 degrees centigrade?

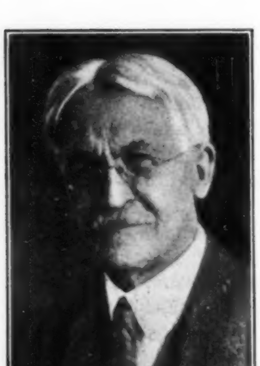
The method devised is as follows: There is first a conditioning stage in which the coal is brought up to a temperature within from 25 to 50 deg. of the softening or pasty stage. This is accomplished in a closed rotating drum which also serves as a heat exchanger for the spent gases from the retort flues. The time element in the preliminary stage is flexible, a quick heating over a period of 15 minutes gives equally good results with the use of a period of two hours. From this stage the coal is poured into a retort already heated to the maximum temperature to be employed, say, 750 deg. cent. In this stage the conditions as to time are very exacting. The average time-temperature curve shows the heat to have penetrated to the center of the mass in from 10 to 30 minutes, under which conditions there will be found a resulting coke which is dense and strong, with all the attending advantages of reactivity and character of by-products so greatly desired and only attainable by absence of excessive temperatures. Material thus produced is substantially free from breeze, and needs only to be crushed and sized to be brought into form for domestic use, for which it is peculiarly fitted, not only because of its smokeless character in combustion but also because of its ease of ignition, retention of fire and ready response to the control mechanism which accompanies the ordinary house-heating appliance, including especially the open grate.

Not the least gratifying result in these experiments has been the fact that the very large class of coals in the mid-continental area, ordinarily classed as non-coking, lend themselves admirably to the process. These coals are true bituminous in type but have a free water content at the mine of from 8 to 16 per cent. This fact and the peculiarly delicate or unstable character of the bonding material for producing the coke structure make it impossible to produce a dense, hard coke at low temperature without following a procedure that recognizes these peculiarities and which, as a matter of fact may turn them to advantage in securing the results desired.—S. W. Parr in a paper at the International Conference on Bituminous Coal, Pittsburgh, Pa., November 15 to 18, 1926.

The Credit Factor in the Structure of Industry

Second Henry Robinson Towne Lecture on the Relation Between Engineering and Economics

By DAVIS RICH DEWEY,[1] CAMBRIDGE, MASS.



D. R. Dewey

This is a world of borrowers. We are all in debt. A German economist a century ago divided the economic history of mankind into three stages: barter economy, money economy, and credit economy. If credit economy was characteristic of the economic world 100 years ago, the present stage may well be termed supercredit economy. Even the apostle of thrift and economic independence may be heavily in debt, although he does not know it. He is a unit of the national government which has borrowed 20 billions of dollars. Measured by income-producing capacity, his individual responsibility for this debt amounts to a goodly sum. And to this must be added the debt of the municipality in which he has his home.

Borrowing is an ancient practice in the life of mankind, but the use of credit has been enormously extended in the last two centuries, and during the past ten years has been developed in most unexpected directions. Apparently we have not yet tested its full possibilities, for new devices for utilizing credit, or ability to borrow, are being invented every year.

Credit in Early Times and Its Abuse

Credit could not develop on any considerable scale until there was an accumulation of capital in the hands of individuals in excess of what they needed for their own personal wants. Nor would borrowing be a common practice unless governments and public opinion were strong enough to enforce the settlements of debts. Both of these factors were absent in the earlier stages of human society.

What borrowing there was until comparatively recent times, was to satisfy personal necessities. The lender loaned from motives of charity, and the borrower borrowed because of personal want. "He is ever merciful, and lendeth," says the Psalmist. Such loans may be regarded as loans for consumption rather than loans for production. Borrowing was a personal misfortune, and, if possible, to be avoided. Religious law frequently protected the unfortunate borrower by making usury or interest unlawful and releasing the debtor, after a term of years, from his obligation.

The development of commercial exploration and discovery in the fifteenth and sixteenth centuries and the growth of manufacturing industry led to the accumulation of capital and its employment in large business undertakings. Banks were founded for the loan of credit, and the use of the bill of exchange for the movement of credit became common.

In the eighteenth century borrowing became a recognized practice. Governmental debts were created; banks were multiplied; the political revolutions and industrial revolutions alike stirred the imagination of the people, and the future held out most alluring hopes. Borrowing grew by leaps and bounds. With the increase of wealth there was an increase of spendthrifts and an increase of failures in business undertakings. In the last century the abuse of credit became a sore problem, both in England and the United States. Nearly 100 years ago (1839) McCulloch, an English economist, stated that seven-tenths of the community were constantly in the practice of anticipating their incomes. "Few of us," he says, "think of paying ready money for anything." "There is hardly one so bankrupt in character and fortune as to be unable to find grocers, bakers, butchers, tailors, etc. ready to furnish him upon credit with supplies of the articles in which they respectively deal."

Where the abuse of credit was great, laws were passed for committing to prison persons who did not pay their debts. In 1841 the editor of the Philadelphia *Gazette* estimated that the total number of persons then lying in prisons of the U. S. for debt was 60,000.

Credit was abused not only by the individuals but by governments. States, even before the Civil War, repudiated their debts. Over-rapid construction of railroads led to receiverships. Corporate credit received a severe blow.

The harsh treatment of debtors was abandoned about the middle of the last century. Our banking system was slowly improved, and gradually business adopted greater care in the granting of credit. But side by side with this increasing caution there has grown up a most complicated scheme or organization of credit facilities, making it easier and easier for the individual, no matter how humble his economic position may be, to borrow. There are national banks and trust companies for the well-to-do, and Morris-plan banks and credit unions for the mechanic and clerk who wishes to borrow $25 or $50 to pay the doctor at the birth of a child. There are land banks for the rich farmer and intermediate agricultural credit banks for the poor farmer. Every class of borrower is catered to in the present stage of our economic development.

New Uses and Expansion of Credit the Dominating Characteristic of the Present Century

In the last century the outstanding agency which transformed and molded the economic life of mankind was the release of mechanical force. In this century the impressive factor is the use of credit. I doubt if it be an exaggeration to state that the new uses and expansion of credit will be regarded by the future historian as the dominating characteristic of at least the first third of the present century.

Credit is the advance or transfer of value for which payment is made at a future date. Practically every kind of business now organized uses credit at some stage of its operations, and most of these continuously. It is sought for in the buying of goods and is granted in selling of goods. Credit serves both the producer and the consumer. Production would not enter into new venturesome paths of enterprise if credit did not lend its support. Railroads and factories are built on borrowed money where credit is extended over a number of years. Without credit old enterprises would cease to expand and come to a standstill. Consumption is stimulated by the use of credit. Many buy their household supplies on charge accounts and make settlement, if punctual, on the first of the following month. The retail store buys of the wholesaler or jobber on credit extending from 30 to 90 days. Every business man or firm in taking stock of his financial resources and liabilities finds that money borrowed and money owed occupy a prominent part in his balance sheet.

Illustrations of Primary Credit

Let us consider, as a preface to the thought which I wish to convey to you, a few familiar figures illustrating certain types of the use of credit. For purposes of comparison, we note that the official estimate of the national wealth of the United States was placed in 1922 at 321 billions of dollars. Thirty-one billions, or a little over 10 per cent of our total national wealth, is the figure for public indebtedness. Governments, the federal, state, county, city and town, and other civil divisions, have sought credit and are indebted to that amount, and this debt constitutes a lien upon the present and future wealth of the nation.

The funded debt of the steam railroads is about eleven billions; for public utilities including street railroads, gas companies, telephone companies, and light and power companies, the borrowings amount to about ten billions. We thus have a total of 52 billions.

[1] Department of Economics, Massachusetts Institute of Technology. Ph.D., LL.D.

Delivered at the Annual Meeting, New York, December 6 to 9, 1926, of The American Society of Mechanical Engineers.

The farm-mortgage debt is estimated at about eight billions, increasing our total to 60 billions. A further addition of six billions covering the mortgage debt of homes not on farms, brings the total to 66 billions. We have now reached more than a fifth of our national wealth. At this figure we also have another unit of measurement, the significance of which we possibly can grasp. Sixty billions represents approximately the total national income of the people of the United States for an entire year. In other words, governments, railroads, public utilities, farmers, and owners of homes not on farms have pledged themselves by definite and explicit promises to pay at some future date an amount greater than the total income of the population for an entire year.

There is also the mortgage debt of city real estate, of hotels, apartment houses, office buildings, and factories, for which we have no precise figures. It must amount to a large sum, for in the single year 1925 the total volume of urban real-estate bonds placed on the market amounted to one billion dollars, and there is in addition the mortgage debt on this class of properties, too small individually to be covered by public bond offerings. In the aggregate this, too, must amount to a large sum.

All of the foregoing forms of loans represent the grant of credit under formal documents of obligation, and may conveniently be termed illustrations of primary credit.

Modern Forms of Credit

Glance at the field of banking, a business specifically devoted to credit. In 1924 commercial and savings banks in the United States owed to depositors 43 billions. This included over 20 billions of savings deposits, as distinguished from checking accounts. On the other hand, these banks were owed 45 billions. Thus a sum equal to one-eighth of the national wealth of the country is in constant ebb and flow through the portals of our banking institutions. Building-and-loan institutions have in addition more than four billions invested in loans.

At the beginning of this year there were over 70 billions of legal-reserve life insurance in force. In other words, life-insurance companies have assumed the responsibility, provided the insured fulfil current obligations, of transferring to the beneficiaries of the insured at some future date an amount equal to one-fifth of the present total wealth of the country.

I would not stop here in listing evidences of credit in our economic structure. Technically, credit implies a relationship creating a legal claim by the grantor upon the property of the person to whom credit is given. What I have in mind, however, is credit in a broader sense, viz., the entrusting of one's property to another's control and management, irrespective of legal implications involved in the transaction.

A person who has surplus funds to invest has the choice of two different kinds of investments. He may lend his funds under an agreement that the sum will be paid back according to certain specified or implied terms. Bonds, debentures, notes, and bank loans are familiar examples of this sort of credit. The creditor has a legal right to sue the borrower if the conditions of the loan be not fulfilled. As far as the essence of credit is concerned, it is immaterial whether there be a pledge of property or collateral by the borrower in order to secure the loan.

Credit, however, as an economic force, and as we see its manifestations today, covers a wider field than that recognized by law. The possessor of surplus funds may purchase stock. Technically and legally he becomes a part owner of a certain kind of wealth, as a railroad, mine, hydroelectric or power plant, factory, or a merchandising establishment. Technically he shares in the profits and losses, and accepts the risks which ownership involves. From the legal point of view there has been no exercise of credit in this form of investment.

When stocks were held by those who actually managed the enterprise, it may fairly be said there was no grant of credit. The rights of ownership and control were represented by stock certificates for the sake of convenience and to take advantage of the benefits of the corporate form of organization. But corporate development has gone far beyond this simple stage. Ownership and management are no longer in the same hands.

Investment in stocks, as far as the average investor is concerned, is a grant of credit. Take, for example, the buyer of preferred stock. The purchaser is a part owner of the enterprise, and as an owner he is technically assuming the risk which ownership involves. But his rights and responsibilities as owner are limited. Rarely does he have a vote which might enable him to exercise some measure of control through the choice of directors or development of new financial plans. In reality the buyer of preferred stocks makes an investment actuated by the same motives as the buyer of bonds who is protected by a lien. He selects the preferred stock instead of the bond because of the higher yield. He regards himself as a lender of money without demanding collateral security.

The same motives influence many purchasers of common stock. They do not invest in order to exercise control or the management of business with accompanying risk. They rarely exercise their voting privileges even through proxies; they may not even know the names of their officers or even where their property is located, or the products which the companies produce. For them investment is simply the grant of credit.

There is nothing startling in this description of our economic life. Credit is no new factor in the relationships of society. We know that we live in a world of credit; we have lived in it in the past and expect to live in it in the future. But nowhere is imagination more needed than in the world of the obvious. The every-day things of life are so apparent that their significance is often dulled and blurred.

The Recent Enormous Expansion of Credit

Why should we conclude that credit is a more characteristic feature of the present era than it has been in the past? The justification for this lies in the recent enormous expansion of credit, penetrating into every nook and cranny of our economic life; the creation of intricate machinery for distributing credit over wide areas, separating the debtor and creditor by thousands of miles; and the application of credit as an agency to remedy social ills.

New kinds of banking institutions have been devised to furnish and utilize credit. At the end of the last century there were national and state banks, trust companies, savings banks, mortgage companies, and private banks. To these have been added federal land banks, national farm-loan associations, joint-stock land banks, and intermediate credit banks. The federal reserve system adds another story to the credit structure, and the foundations enlarged by decreasing the amount of legal reserves required to support the weight of credit which towers above. The credit obligations of banks and trust companies were five times as great in 1925 as in 1900.

Acceptance companies have further facilitated the use of commercial credits—and finance companies are organized to carry the credits created by instalment selling. On a humbler scale, credit unions and Morris-plan banks, established only a short generation ago, are growing in number and extend the service of credit to thousands whose incomes are small and precarious, and to whom the ordinary avenues of credit are closed. Commercial banks have invaded the field of savings banks and are rapidly outstripping them in accumulating the small savings of the thrifty. The Federal Government has also established the postal savings system, so that practically every individual in the nation is brought into close contact with agencies of credit.

Of the wide distribution of securities it is hardly necessary to speak, so much publicity having been given to the subject in the past few years. Investment bankers have multiplied in number—their energy and zeal in placing securities is excelled by no class of merchandisers. The path to investment in securities is made easy by instalment payments. According to one circular recently read, the lender is insured free of charge against failure to make the deferred payments. In other words, an indemnity company assumes responsibility for the investor in case of disability.

Another evidence of the expanding range of distribution is seen in the sale of securities by public-utility companies to consumers. Thousands who would never have purchased through the stock-broker or investment banker, have seized the opportunity to enter into a credit relationship with which they never before had had any experience.

An interesting recent development of the use of credit is seen in the labor movement. Opportunities are given to employees to purchase stock on easy terms and at an attractive price, and the

total amount of stock thus owned is said to be large. Organized labor has also established labor banks and investment companies. In other words, labor is experimenting with the credit tools of capital. Some place great stress upon the significance of these new credit relationships and ties—particularly as to their effect upon the so-called conflict of capital and labor. Whether or not this justifies optimistic hopes for the solution of the labor problem, it does mean, if these experiments are continued and meet with a reasonable degree of success, that the meshwork of credit will be enormously enlarged.

Instalment Buying

Instalment buying is another example of credit. It is not new, for real estate, farms, houses, and furniture for many years have been bought on the partial-payment or instalment plan. Its extension to an ever-widening list of commodities has aroused much discussion. Three-fourths of the automobiles are sold on credit, and instalment buying now includes radio sets, phonographs, washing machines, refrigerators, and clothing. It is estimated that the amount of sales of instalment goods during the past year was over six billions. A very considerable part of these credits was advanced by finance companies, specially organized for this purpose, and these in turn obtain credit from banking institutions. We have here an illustration of credit employed to stimulate consumption. Of course, if consumption is increased, production also will be increased. But credit is here put, on a large scale, to a use to which we have not been accustomed. It is probably too early to test the soundness of these credits. Although some are apprehensive that they will not stand the shock of a business depression, if one should occur, others believe that the bulk of these credits has been managed in an orderly manner and is as well founded as the more familiar credits to producers.

A characteristic feature of instalment indebtedness is that it is voluntary and not forced upon the buyer or debtor because of misfortune or want. Such buying and incurring of debt may be imprudent and show poor judgment; but it is a step in the development of the credit relationship under orderly procedure and supervised management. Well-organized credit facilities make for thrift. We are too apt to measure thrift solely in terms of deposits at a savings bank and a life-insurance policy. These protective safeguards are to be encouraged. But thrift does not spring up spontaneously. It has its origin in the desire for a future and endurable satisfaction rather than an immediate, temporary, and perishable satisfaction. It is therefore possible that this recent development of credit relationships involved in instalment buying may have thrift as a by-product. It is said that $500,000,000 are annually deposited in banks by Christmas clubs; twenty-five per cent of this, however, is not withdrawn for the purpose originally designed, but left in the investment. So we see thrift as a by-product.

Credit as a Remedy for Economic and Social Ills

Of the use of credit in remedying social and economic misfortune, two illustrations may be cited. The time-honored method of clearing the competitive market of surplus goods and equaling supply and demand has been by adjustments in price. The use of credit as a substitute for price reduction is becoming more frequent. A striking illustration of this is occupying the stage at the present time in the South. An unexpectedly large yield of cotton has lowered its price below the cost of production for a portion of the crop. Loss naturally results. To check the decline in price and prevent greater loss, credit has been called to the rescue. Cotton will be withdrawn from the market and stored under control of banking and credit agencies. Of like intent were some of the bills before Congress a year ago to furnish agricultural relief to western farmers. These proposals are cited simply as evidence of the increasing tendency to solve emergency difficulties through the tonic of credit.

The most notable illustration of the emphasis placed upon credit as a remedy for economic and social ills is seen in the discussion of European affairs. We are told that Europe cannot pull herself out of the chasm in which she is plunged unless capital resources are advanced from without. Europe must be rebuilt by credit. Self-help is not sufficient. We are even told by some that the people of the United States should lend to European enterprises in order to maintain their own prosperity. We must loan to Europe in order that Europe may have the wherewithal to buy from us. If loans will increase production, there is sound business sense in this proposal. We are loaning large sums to business enterprises in foreign countries, and the flow of credit breaks down all national and political barriers and boundaries. Europe, to say nothing of South America, is being scoured by emissaries of American investment bankers for opportunities for credit offerings to be scattered far and wide to lenders of our country. Since the war, Americans have loaned to foreign countries, including private business undertakings as well as governments, approximately ten billions.

Enough examples have been given of the widening range and penetrating activity of credit. We all probably agree that credit has been a most powerful agency in the development of our economic resources, that it facilitates business and is a help in time of need.

More significant, however, than the services which credit renders, more significant than its extension and the new purposes to which it has been put, is its testimony to social progress. Credit, as we see it today, would not be created and utilized unless there was mutual trust and confidence. This confidence may be ill-founded, but the supreme fact to notice is that confidence exists. It cements society together. Superficially, it may be thought that the units of business are leaning upon each other for support and that consequently business as a whole is unstable. In normal times, however, this mutual support does not signify instability, but if anything, increased strength. Moreover, the mistakes of one are shared by others, and, through the delicate mechanism of credit, losses are scattered far and wide. If credit be protected at the fountain head the mistakes need not be many and the losses will be comparatively infinitesimal. As the boundaries of credit are widened, the ties which bind society together are multiplied.

I am inclined to think that we place too much emphasis upon political arrangement and machinery as a means to achieve our social ideals. We believe in democracy as the ideal form of political society. We sometimes wonder whether democracy as a political institution will endure, and in our despair conclude that, if it does not last, civilization will retrograde. We certainly hope that democracy will endure and attain a still more perfect pattern, but true democracy means more than a form of political government. It involves harmonious economic relationships, and not the least important among these is the confidence and mutual regard which we witness wherever sound credit is bred and nurtured.

Equal opportunity is one of the fundamental ideals of democracy—equal opportunity not only to share in the responsibilities of government, but equal opportunity for self-development, equal opportunity to work, and equal opportunity to utilize the rewards of work. The great mass of the population is unfitted by training and unfitted by mental endowment to take the lead in exploring and conquering the great material resources of our country; they must, in order to utilize fully the rewards of their work, entrust to those who have the capacity for leadership that part of their wealth which they do not immediately consume. This demands confidence. Confidence is the twin-sister of opportunity in economic democracy.

Quality of Credit the Desideratum Rather Than Its Quantity

We should be more concerned with the quality of credit rather than with its quantity. We are in danger of relying too much upon the mechanism of credit institutions with all their varied and ingenious tools and appliances for distributing credit risks. Credit agencies, however elaborate their paraphernalia may be, will not necessarily be a security against disturbance and disaster. Who can appraise credit and determine whether it be fit for distribution? Here is the vital point upon which attention should be focused. Facilities for moving credit are a welcome addition to our economic equipment, but we must make sure that the credit which is dealt in is sound and not adulterated.

In seeking capital for an enterprise, technically known as promotion, there are three agencies which coöperate. First, the engineer and accountant who investigate the physical property; second, the legal expert who scrutinizes the proposal that it may con-

form with corporate law; and third, the investment banker, who determines the character of the issue and the best method of distributing the offering.

I would not minimize the importance of the lawyer and the investment banker, but is the service of the engineer and accountant sufficiently emphasized? The credit risk must be dissected and analyzed, and its quality accurately tested. In this analysis the engineer plays an important part, particularly in the field of credit to be utilized for the construction of public utilities, hydroelectric plants, and the like. His responsibility is great, and as far as I am aware, has not been abused. How far his power goes, after his data have been assembled, you are more competent to judge than I. If his investigation be purely formal, to be lightly set aside when it does not accommodate itself to ambitious financial plans, a grievious wrong may be committed.

Engineers' Signed Statements Should Accompany Those of Legal Firms and Accountants in Credit Offerings

The engineering and allied professions have a great opportunity to insist upon the employment of professional standards which will command the confidence of the investing public. There may be practical objections, but why should there not be a universal custom of signed statements by engineers to accompany the signed statements of legal firms and accountants which appear in investment circulars?

It cannot be expected that the analyst—whether engineer, accountant, or statistician—shall be held legally responsible if the credit risk goes wrong; for there may be mismanagement after the credit is issued; but there is a moral responsibility on the part of those who create the credit offering and those who distribute and merchandise it to make certain that as long as the credit is in their hands it is sound and will prove a blessing to those who use it.

Like electrical energy—a mysterious force in the physical world—credit is capable of most beneficent service to the wants of society; each, however, can be perverted by the slightest error to do untold damage. Governments have misused credit and banking institutions dishonored the trust placed in them. Fortunately we have a reasonable assurance that such errors will not be repeated on any widespread scale in this country. Credit bureaus, under the stimulating activity of the National Association of Credit Men, are endeavoring to check abuses in the merchandising of goods. State legislatures by blue-sky laws are seeking to prevent the sale of fraudulent and imprudent securities. The misbranding of credit is so easy, however, that its protection should not be left to governmental officials and organized private agencies, but should be a matter of concern to every individual and profession.

The Development and Application of Tractors on the Pacific Coast

At the Spring Meeting of the A.S.M.E. held in San Francisco, June 28–July 1, 1926, a paper entitled The Development of the Caterpillar Tractor and Its Application to Industry was presented by Pliny E. Holt, Mem. A.S.M.E., of Stockton, Cal. In this paper the author reviewed the history of the caterpillar-tractor industry by considering the following six distinct periods in its development: namely, historical; inception of the idea of the endless-track principle; development of the idea into a workable machine; the caterpillar in the World War; standardization of parts and refinement in manufacture; and universal application to industry. Interesting discussions have been received which deal with early experiences with steam and gas tractors on the Pacific Coast and with the use of the tractor for draft or field work, and these are given below.

Early Experiences with Steam and Gas Tractors[1]

California stands out in the industrial world with unusual emphasis on two particulars, namely, in the matter of the development of her hydroelectric resources with her interconnected net work of distributors, and in the matter of mechanical power application in the harvesting of her vast agricultural resources. The paper of Pliny E. Holt graphically describes one of the most dramatic incidents in this later development, namely, the evolution of the famous caterpillar tractor.

Comparing the early steam tractors, it will be noticed that the eastern tractor builders worked from the opposite direction from that of the two leading California tractor men, Holt and Best. The eastern tractors were very similar to the portable engines. The boiler was also the main frame. The engine was mounted on top of the boiler, and connected to the drive wheels by sprocket chains or a train of gears.

Both Holt and Best developed their tractors from the opposite direction. Instead of trying to apply an existing type of engine to a new purpose, they analyzed the requirements a tractor would be required to meet, and then designed a machine especially to fulfil them. First, a powerful frame was built, heavy enough to withstand the severe strains of hauling service. On this a boiler and engine were mounted, both engine and boiler being especially designed for this service. In laying out the complete machine the weights of the various parts were distributed, as far as service conditions permitted, in such manner as to bring the best all-around results.

It can readily be seen that by proceeding along these lines the western men were far in the lead from the very start. Later, the eastern builders modified their designs somewhat. Some built a frame and mounted the engine on it under the boiler (which was of the locomotive or water-leg type) forward of the firebox. One builder built a framework to carry the engine, but left the engine mounted up over the boiler. In all of these designs, however, the boiler was still part of the tractor frame, and carried the main part of the strains set up in service.

When the gas tractors were first developed, C. L. Best retained most of the features of his steam tractor, except that he substituted a marine-type gasoline engine for the steam engine. The eastern men seemed unable to break away from tradition, and their tractor appeared to be a gas engine mounted on a wagon frame, and connected to the rear wheels for tractor purposes as an afterthought.

In 1911, during the construction of the Coleman ditch of the Northern California Power Company, in Shasta County, there were two Best steam tractors on this job. One was of 110 hp., and the other of 85. Each tractor pulled a 20-ton-capacity, four-wheel trailer wagon. The large capacity of the trailers was in order to carry heavy machinery parts to the power houses. The machines were kept in constant service for heavy freighting. Each trail wagon carried an auxiliary steam engine supplied with steam from the tractor boiler, for use on heavy grades.

It is interesting to note that the run of these engines was about 20 miles from the railroad at Anderson, as far up the ditch as Camp Asbury. An oil wagon, holding sufficient oil for the round trip, was carried behind the trailer. There was also a small fuel tank on the tractor. The roads, such as they were, were only country dirt roads, and for the last part the route was across the open field, where the soil was black adobe. The tractors were put in service in the spring as soon as the ground hardened sufficiently to carry their weight. One noticeable piece of equipment for each tractor train was a set of blocks and several hundred feet of steel cable. These were in constant use in dragging the trailer out of holes and soft spots. On some occasions the trailer was partly unloaded, and a return trip made for the rest of the load. "Dead men" for the cables were usually the scrub-oak trees that dotted the country.

These tractors were powerful pullers and very reliable, but under some conditions they had their drawbacks. They were designed so that their weight was mainly over the rear wheels, to improve the traction. Further to accomplish this they had vertical boilers.

[1] By Robert Sibley, Consulting Engineer, Berkeley, Cal. Past-Vice-President A.S.M.E.

The tall boiler made them a little topheavy. With a very heavy pull they would rear up and lift the front wheel off the ground. The water tank was mounted on the frame forward to hold the front end down. When this was empty the tractors were difficult to steer when pulling heavy. Even if the front wheel did stay on the ground, it would plow up the ground (even though it did have a center flange) for a distance before taking effect and making the tractor turn, even with the steering wheel hard over. In soft ground there were conditions where these tractors, if the pull was too heavy, would slip their driving wheels and dig holes, and cleats only had the effect of speeding up the digging.

Another observation of tractors in action may be cited, this time on the Chowchilla ranch in California in 1913. There were two wheeled tractors in action, one a C. L. Best gas tractor, and the other a steam tractor of an eastern type. For a period of three months these machines were under close observation, operating under similar conditions, and the comparison was all in favor of the gas tractor.

The steam engine was of the type referred to earlier. It required two men to handle it. Its water tank required refilling every three hours, and the fuel tank every 15 hours. A teamster was constantly on the job hauling fuel and water to the tractor. The boiler was horizontal. The ground was virgin land, never plowed before, and covered with humps and hollows. This made life miserable for the fireman, because if he carried his water high, the boiler primed and caused knocking in the cylinders, while if he carried it low he risked burning the crown sheet.

The gas tractor was one of the earlier C. L. Best machines, with a 60-hp. Buffalo marine motor. One man could easily handle it. The fuel and water problem with it was very simple compared with the steam tractor. One filling of the radiator would do for several days, and with its smaller fuel consumption it could carry fuel for longer operating periods than the steam machine. With its low-slung frame and low center of gravity it ran much more steadily over rough ground and handled easier.

An experience with another eastern steam tractor will show the drawbacks of a steamer. For this particular service, water could only be obtained at points a long distance apart. The experiment was tried of slinging six 100-gal. drums, three on each side of the tractor, in addition to the regular fuel and water tanks. Extension wheels were added to carry the extra weight. After filling the water tanks at one stop, the tractor happened to run over a rock so that the weight on one side suddenly came on the outer tip of one of the extension wheels. The result was a broken axle. The builder of the tractor had warned the owner that he might expect this to happen.

Unfortunately, the writer has not had sufficient experience with the caterpillars to go into fine details. However, he can point how how some features of the caterpillar design offer a solution to the drawbacks of the wheel tractors.

One difficulty of the wheel tractor is to arrange the weight distribution. If too much of the weight is over the front wheels, it is not available for traction on the drivers. On the other hand, if it is shifted too far back, on a heavy pull the tractor will rear up and lift the front wheels off the ground. In the modern caterpillar the front wheel has been eliminated, so all the weight comes on the tracks. The weight is distributed so as to keep down the tendency to rear up, but it is always available for traction.

The caterpillar can be turned almost where it stands. Its construction permits of a broad pair of tracks with small overall width, and of slinging the center of weight very low down. It also permits placing the motor very close to the point of application of power.

One remarkable feature about the development of the caterpillar is that while at first tractor men regarded the wheel tractor as the all-round machine and the caterpillar one for special requirements, actual experience has proved that the caterpillar is the universal machine while the wheel type is the one of limited application.

To really appreciate the development of the caterpillar tractor it is necessary to examine one closely, and preferably to see it in action in charge of a skilled operator. A man of mechanical training, even if he has had no previous experience in the operation of tractors, can then realize the remarkable ingenuity that has been displayed by the designers of the caterpillar in developing a practical road locomotive that will meet all heavy hauling requirements.

In conclusion the writer wishes to express personally his appreciation for many detailed items included in this discussion which he drew from close contact and correspondence with Mr. Howard Livingston, of Stockton, California.

The Use of the Tractor for Draft or Field Work[2]

ANIMALS have been the source of field power since the beginning of agriculture, until the advent of the tractor. However, the horse, ox, or any other animal can do work in but one way, and that is by draft, or pulling the load. For that reason all agricultural field implements have, until recently, been designed to operate by draft. If rotary motion was needed it was obtained from a driving wheel such as in the early binders and combined harvesters. The tractor, on the other hand, is not essentially a draft machine, its primary motion being rotatory, the energy being delivered as torque at the crankshaft.

Recent developments in the power take-off point the way toward a new era in the application of power for field utilization. Inventors have for years been stimulated by the possibilities of the rotary tiller, and each year sees many new machines of this type.

The gas tractor has quickly taken a prominent place in agriculture. In 1910 it furnished but approximately one per cent of the farm power, while in 1920 it furnished 10 per cent. It is difficult for us to realize the magnitude of this increase of 1000 per cent in ten years. The tractors on the farms in the United States furnish annually close to one billion, six hundred million horsepower-hours of energy. Many are surprised when they learn that the forty-seven million primary horsepower employed by agriculture is 25 per cent greater than that used by all manufacturing in this country. Primary horsepower as here used is the equivalent of the electrical engineer's term "connected load." However, the manufacturers secure from their power installations over three times as much energy per year.

The load factor for all farm power in the United States is approximately 3 per cent. That this load factor may be improved with the use of mechanical equipment is well illustrated by the situation in California. Fifty-seven per cent of all field power in this state is furnished by tractors, horses and mules furnishing the remainder except for a small amount developed by cable plowing outfits. Electric motors furnish on our farms about 20 per cent more energy than both animals and tractors combined. The load factor for all farm power in California is over 7 per cent, and for electric power alone, 13 per cent.

A study by states[3] of the amount of power utilized per acre, the volume of production, and the net income per farm operator, clearly indicates that an increase in the amount of power used is accompanied by a comparable increase in production and income.

There are many farmers in the United States who are now utilizing five different forms of energy: manual, animal, internal-combustion, wind, and electric. In many cases the internal-combustion engine is utilized in separate units for stationary engines, tractors, and trucks. By increasing the load factor of his present primary power and by utilizing a still larger amount of energy the farmer will very materially reduce his present handicap in his competition with the other industries.

In laying the 65-in. steel pipe line of the Mokelumne water-supply project for the East Bay Municipal Utility District in California, about 26,000 ft. of the line was first connected up by butt-welded circumferential joints made in the trench. Before the line had been completed it was found that satisfactory field welds could be made only with great difficulty, and a change to riveted butt-strap joints was accordingly ordered. The reason for the change was that the large diameter of the pipe made it very difficult to equalize temperatures so as to avoid internal stresses in the metal plates.—*Engineering News-Record*, December 2, 1926, p. 912.

[2] By L. J. Fletcher, Agricultural Engineer, University of California, Berkeley, Cal.

[3] U. S. Department of Agriculture, Bulletin No. 1348: An Appraisal of Power Used on Farms in the United States.

The Changing Relations Between Employer and Employee

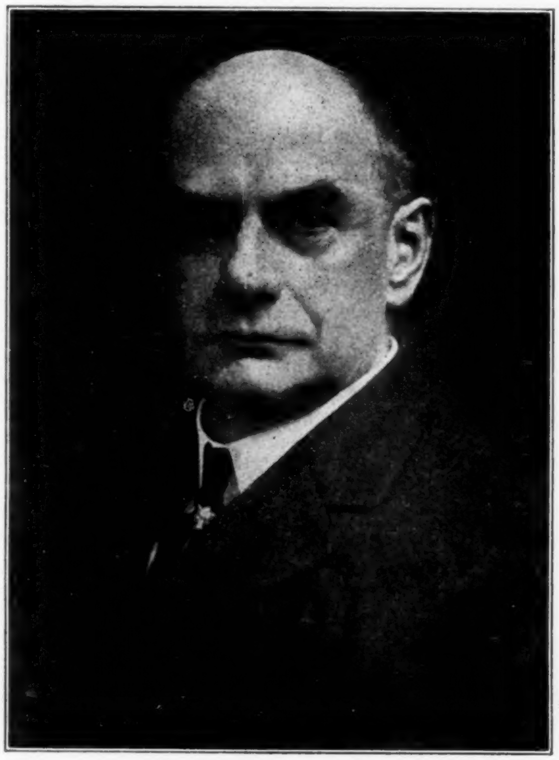
The Growth of the Corporation—The Newer Understanding Between Employer and Employee—Conditions in the Building Trades and the Coal Industry—The Dawn of a New Order and the Part of the Engineer Therein

W. L. ABBOTT,[1] CHICAGO, ILL.

THE great civilizations of the past, with their achievements of wealth, learning, and culture, were for the favored few and rested on the shoulders of the enslaved masses, whose unrequited toil, however poorly directed, piled up great wealth for the master class, leaving the masters' time free for pleasure and for war or for the pursuit of learning and the fine arts; and be it said in passing that the accomplishments of the masters in those fields of endeavor remain, after the lapse of hundreds and of thousands of years, the classics of the world.

The ratio of the numbers of slaves, serfs, thralls, peons, or bondmen of other names to the numbers in the master class naturally varied with the age and with the country, but may be taken as ranging from one to six—for the most part sullen or broken-spirited slaves who grudgingly wrought under the threat of the lash, without hope of present or future reward.

Compare the condition of that patrician of the olden days, surrounded by his slaves, with the standing of the American workman in this day of steam and electric power. This modern patrician, with his mechanical aids before him, has at his hand and command an amount of power equal to the strength of scores of tireless slaves of the greatest skill, willingness, and discipline. As the slave of the past brought to his master wealth and, in its train, ease, learning and culture, the slaves of the present-day American toiler are making him the richest workman the world has ever seen, and these riches, too, are bringing their gifts of pleasure, comforts, education, and culture. This condition of the American workman is the product of two principal factors, the first being the introduction of power-using and labor-saving machinery, designed to enable the worker to vastly increase his production; the second, and equally important, factor being the desire and will of the worker to use this improved equipment to the limit of his physical strength and endurance in attaining the greatest possible result.



W. L. Abbott

The Family of Craftsmen

This situation is a comparatively recent outcome of a long series of slow changes in the relations between employer and employee which have been going on for one hundred or two hundred years, or since the time when the manufacturer wrought with members of his family in his home or in his little shop near by. Sons and daughters were trained in the arts of the parents, and all working together as a family group, spun and wove or fashioned metals or clay by main strength. If it were found mutually advantageous for a neighbor's son or daughter to be admitted to that home circle of industry to learn and to produce, that apprentice shared not only in the long, hard work and small pay, but in the sentiment and society of the home as one of the family; and what was true of the apprentice remained true of him after he became a journeyman, as long as he cast his lot with that family and employer. Here began the voluntary relations of employer and employee, master and man, capital and labor, and with that relation went the personal touch, accord, and complete understanding born of the intimacy developed during the long hours of labor and afterward. Nor did that intimate relation suffer any material change when the household prospered and, one after another, workers were added to the circle and the detached shop definitely succeeded the home; the master was there among them and of them. He directed their efforts, perfected their technique, provided material, and found markets. They, in turn, brought him skill, diligence, and devotion, and rejoiced and shared in his success.

However, increasing prosperity and volume of business must in time change the status which was of the home shop. The master's head outweighed his hands. More and more of his time was spent in buying and selling, in accounting and financing, so that the workers got to see him less and less. Because of their numbers they were no longer members of his household, nor could he keep in touch with their personal affairs as formerly. True, indeed, the master still had a cheery greeting for his old-time shopmates whenever he met them, and their loyalty to him was unchanged, but with the newer men he had little in common aside from the work on which they were engaged.

The Growth of the Corporation

The shop continued to grow until it surpassed the ability of the master and of his friends to finance it, steam was harnessed, and machinery perfected. Then slowly came the inevitable corporation, which separated by miles master and men, who already had drifted far apart. Executive cares engrossed their old-time friend and companion. Foremen and superintendents intervened, and while the company and its officials were visibly prosperous, the men had no seeming part in that prosperity. Long hours, hard work, small pay, irritations, and disagreeable conditions, which formerly were taken as a matter of course from the master, would not be endured for the corporation. Unable now to pour their troubles into the sympathetic ear of their old counsellor and thus find solace, they discussed their grievances with each other and so multiplied their woes and became originators and disseminators of ill will.

This change did not come about in a decade nor in a generation, but over a long lapse of time, covering the period when workmen were being employed in greater numbers and in larger shops, made possible by the introduction of power and power-using machines.

In shop, mill, mine, and forest, on land and on sea, this change

[1] Presidential Address at the Annual Meeting, New York, December 6 to 9, 1926, of The American Society of Mechanical Engineers.

was taking place, the better-managed companies growing larger and absorbing the smaller. Stockholders, represented by boards of directors, in intimate touch with and superior to the management, considered large dividends the objective to which all else should be subordinated, involving the cutting of costs wherever possible, including the payroll and rates of pay.

Periods of depression were weeks and months of unemployment, which the men sought to forestall by slowing down to make the work in hand last longer, and any reduction in payroll and rates of pay was countered by a reduction in rate of output.

Under such circumstances human nature were less than human if the workmen did not come to feel that they were abandoned—worse, exploited by the owners, and reduced to pawns in the enterprise—that they were of one class and the owners of another; that to obtain a better wage and to correct senseless and irksome conditions and to share in the company's prosperity, mass action and war were necessary. And so it came to that, and war—as ever, cruel, stupid, blind—was waged for generations. The mass, in the exhilaration of seeing triumph, imposed onerous conditions upon the employer and the industry, ignoring the injury done to itself by these acts. It was being avenged for ancient wrongs, and for the present that was enough. The employers fought fire with fire and vengeance with vengeance, and as the tide rolled back and forth across the industry, both lost and both won. Both lost in the chaos of the business on which they mutually depended for a livelihood. Both won in that out of the moil came a better understanding that each was indispensable to the other, that employees could not prosper unless the employers did, and that to get the best out of human beings their human instincts should be considered and their human interests enlisted.

The Newer Understanding Between Employer and Employee

The new condition was essentially a return to the sympathetic relations which existed in the family group in the workshop of a previous century. The intimate social contact is, of course, no longer possible and no longer desired, but the right of a workman to be respected as a man and not treated as a machine, and to have the privilege of making suggestions not only for the advancement of his own interest but for the betterment of the work of the shop and for the general good of the company, is not only granted but desired by his employer.

Gone is the hostile array of sullen workmen and arrogant superintendents, the inclination to skimp wages wherever possible, and the counter policy of restricting output and doing as little as possible for the highest wages that can be extorted. The mere creation of an impartial court for the hearing of grievances has reduced the number of such complaints to the vanishing point. Different groups of workmen vie with each other in efficiency and in loyalty, while the individuals are given all possible aid in expediting their work, and their pay increases with their increased efficiency, a liberal amount of these earnings being invested in the stock of the company for which they work. Due to his financial and friendly interest in his employing company, the workman's former policy of doing as little as possible is now changed to one of doing all he physically can, and while his earnings mount to heights that are the amazement of workmen of the world, the employer enjoys an unprecedented prosperity.

The Millenium Has Not Arrived

I would not leave the impression that the millenium has arrived and that the academic question of the relations of capital and labor has been settled finally and for all, with nothing else to be done. Progress is being made daily, and all hope that progress will continue indefinitely, but the results already achieved are so far in advance of the situation twenty-five years ago, or even just before the World War, that there is little possibility of a return to the former status.

London Trade-Union Mission Found Coöperation and High Wages

A few months ago the industries of this country and of Great Britain listened with marked attention to the report of a delegation of eight British trade unionists, selected by their respective unions and sent to this country at the expense of a London newspaper to investigate at first hand and to discover and report upon the secret of the prosperity of American industries and the high wages paid to American workmen, at a time when English industries were depressed and there was so much unemployment among their workmen. A study of the reports of the members of the Mission shows that they were singularly open-minded, of a high order of intelligence, and keen observers, and yet, as might be expected, their trade-union bias occasionally crops out.

The Mission, as it was called, spent six weeks in America, visited several cities, and examined carefully into the workings of forty-two shops, talking freely with superintendents and workmen, and upon their return home each member of the Mission made an independent report of his findings and impressions.

Six of them say directly that the cause of American prosperity is high wages.

All comment on the cordial, even friendly, relations existing between management and men, and the absence of lines of demarcation between the two groups.

All comment on the high rate of production of the workmen, with earnings in proportion, and the eagerness on both sides to speed production to still higher rates with still higher pay.

Following are a few excerpts from these reports, which are more illuminating than any general discussion of them would be:

> The feeling between employers and workmen appears excellent. A feeling of confidence in each other, which is sadly lacking in the old country, was evident everywhere.
>
> The men have an instinctive knowledge that no more can be taken from industry than they and their employers put into it.
>
> The workmen on their part seem to be convinced that to maintain high wages they must maintain high production, and they seem to be just as ready to talk of high productive methods as are the employers.
>
> Everywhere . . . they not only pay more but pay it eagerly, and on all sides have expressed a desire to pay still higher wages, provided, of course, they receive higher production in return.
>
> I have approached this question of mass production with all the prejudice of a craftsman and have been driven to the conclusion that work on mass production is neither soul-destroying nor nerve-racking.
>
> The members of the mission were much interested to learn of the facilities granted by the larger firms to their workmen to purchase stock on somewhat more favorable terms than were available to outsiders.
>
> Employees are everywhere encouraged to purchase shares in the company which employs them. . . . That the idea is popular and taken advantage of is proved by the fact that in some of the works visited 100 per cent of the employees are shareholders, and in no case where the system was in operation was the percentage less than 15.
>
> With regard to the position of trade unions in America, I think it must be frankly admitted that they are without influence in the engineering industry. Employers everywhere stand for the open shop.

Lord Buckmaster, former chancellor of England, summed up the reports of the eight union labor investigators in a chapter on good will, in which he said:

> No one who has ever been in the United States can have failed to realize that this point (the spirited coöperation and fellowship) upon which such emphasis was placed, lies at the center of their commercial success. The next proceeds from the first. It is the willingness and eagerness of everybody to increase output. Without the common fellowship and common purpose of all, this result is impossible.
>
> In the last resort there is opportunity on the land, both in Canada and the United States, for any man of vigor . . . and that fact . . . prevents workmen from being faced with the abyss of unemployment, which over here too often stares them in the face. It is their dread of this catastrophe to which are due all the influences that limit output. If a man lays 1000 bricks a day, he is, according to this view, doing the work of two men, each of whom could lay 500, and this fact obscures the greater fact that the larger the output the more work there is to do.

After this review of the findings of the British Union Labor Mission of comparative conditions in the manufacturing industry in the two countries, we are disposed to wonder at the short-sighted policy of British workers in following their time-honored policy of demarcation and restriction of production, but lest we of America become "puffed up" over our assumed superior wisdom and good sense in such matters, let us in all humility take a brief glance at conditions in some other of our industries: building trades and coal mining, for instance.

Conditions in the Building Trades

The building trades, from their very nature, easily lend themselves to unionization. Their work must largely be done locally.

It is done but once for a single owner. The added cost due to union domination and union conditions is much less than the cost of union opposition and strike delays. Hence the inclination to proceed with the work, in full realization that often the labor costs will be from two to three times as high as they would be with non-union labor at the same hourly rate, all due to the policy of making more days' work for workingmen out of any given job.

Brick masons, usually the most reasonable of the building trades, are satisfied to lay 500 bricks a day, when two or three times that number would not be excessive.

Painters have a motto and admonition reading, "We work too hard when we work. That is why the jobs don't last. Slow up." Plumbers used to have an unholy alliance with the manufacturers and master plumbers to keep outsiders from doing plumbing work or even getting plumbing fixtures, and around these rules and practices, restricting a day's work, cluster many ancient jokes. And so on down the list. Some unions are not so bad and some are worse, but in the pronouncements of none is found anything approaching a declaration expressed or implied for a full day's work for a full day's pay.

The policies and practices of the building trades often constitute the most glaring of union oppressions, and yet so difficult is it for architects and builders to maintain a consistent policy in opposition to those oppressions that in the building trades will probably be found the last stand of labor unions.

The Coal Industry

Whatever may be the policies of coal operators at the present time and however just and liberal may they be in their dealings with their employees, they cannot in one, two, or three decades erase the memories of the wrongs and indignities perpetrated by grasping mine operators upon ignorant and unorganized miners, who were at last aroused to rebellion against their oppressors, and following victory imposed humiliating conditions upon their employers, some of which unwise conditions contained the germs of elements which would in the end cause the disintegration of the very organization under whose banner they obtained their freedom.

Following the conquest of the bituminous coal mines, mining rates were advanced, mine discipline upset, and mine management forced to endure humiliating and arbitrary rulings from all-powerful pit committees. This was of no great concern to the public, and the operators received scant sympathy from it. On the contrary, they became still more unpopular because of the necessary advance in the price of coal as a result of new labor rates and conditions. The miners greatly profited and the public paid the bill.

About this time undercutting mining machines were introduced, materially reducing the time and labor required to get out a ton of coal, but the miner claimed and got the same rate per ton for his work as he had received when he was obliged to lie on his side and laboriously undercut the coal seam with his pickax. As the undercutter and mine electric haulage which came along about the same time materially increased the output and reduced overhead per ton, the miner was allowed all of the direct savings resulting from the introduction of the undercutter. Now, however, when the miner's remaining duties consist principally in shoveling coal into pit cars and it is proposed to introduce an expensive time- and labor-saving machine to do this work, and there is prospect of fewer days' work for miners or perhaps a lower cost per ton for coal, there is serious objection to the introduction of the loading machine. It is said that in England the union has solved this problem by forbidding the miners to load more coal by machine than by hand. In America the miners propose to take all of the savings themselves, leaving none for the public and none to repay the operator for his investment. Little wonder that coal loaders are not being developed and installed.

An equitable distribution of the savings to be realized from the installation of labor-saving apparatus would be a substantial increase in the employee's pay envelope and a decided reduction in price to the consuming public, while the employer, after receiving an amount sufficient to warrant the additional investment, would benefit principally by the increased business which would result from the reduction in cost of the product. To give the entire saving to either employer or to workman or to divide it between them would be unfair to the public, and to give it all to the public would discourage further improvement.

As a result of union policies, there has been a rapid development of non-union mines and mining districts, so that whereas three years ago union mines produced two-thirds of the soft coal of the country and non-union mines one-third, these proportions are now reversed, the non-union mines now producing two-thirds of the country's soft coal and the union mines one-third.

The opening and operating of many small mines in non-union fields while the large and well-equipped mines in union fields stand idle is, of course, economically wrong, but it appears to be the only way to correct some of the recognized faults in the coal-mining industry, which is necessary to pave the way for higher returns for miner and operator and lower prices and a more dependable supply to the public.

It appears that in the long run the Golden Rule works itself out in business as elsewhere, and where employee or employer is by chance able to exercise a tyrannous monopoly over a public necessity, he will in the end be deposed by results flowing from his own acts. But meanwhile the payment of the tribute which he extorts is passed on from hand to hand down the line, until it reaches the burdened and bent shoulders of the country's ultimate producer and consumer—the farmer.

It is unnecessary here to add other examples of absurdities of the workings of rules intended to benefit the workingman at the expense of the public, by restricting output and increasing the cost of the product. Every engineer has had his own difficulties of this kind to contend with.

The Dawn of a New Order

But there is great promise that a new order of things is about to dawn, and as already millions of workers are employed under conditions which provide for frank interchange of views and discussion of differences between men and bosses, and all cordially unite to deliver to the public the best product at the lowest consistent cost, it may, with some assurance, be said that the new order of things is here—the reconciliation of capital and labor—a consummation which has been devoutly wished for since one man first worked for another.

The coming of the new order was not arranged by law or in convention or by following doctrinaire theories of repression or of confiscation. It came almost overnight when it was realized that in any discussion of the relative rights of employer and employee, no settlement can be enduring or permanently beneficial which is not just to the public; that those serve themselves most who serve the public best, and that there is no end to the market so long as the product is being constantly improved and its cost reduced.

That this is true is shown by the stability of our business conditions while there is so much depression elsewhere, and by the admiration and envy with which the world seeks to achieve a prosperity similar to ours.

Our present condition of labor not having been brought about through the intervention of those who professionally pose as the champions of workingmen, is regarded by them as a menace to the institutions and theories which they represent, and already threats are heard that this new cordial direct relation between workmen and employer shall be disrupted, that they and their influence may intervene.

What is the outcome to be?

The answer is largely in the hands of operating and superintending engineers.

The Part of the Engineer

You have long and carefully studied the characteristics of the materials you employ, that your treatment of those materials may best adapt them to the service of mankind. Have you been as considerate of the characteristics of the human bodies and human souls that enter so largely and vitally into your products? Herein lies the hope not only of employer and employee, but of society itself.

With such knowledge it should be possible to build a perfect house of industry, wherein are combined all essential features in

proper proportion and place, in beauty, harmony, strength, and permanence. For stability such a structure should have its three widespread supporting columns firmly anchored to the foundation stones: justice to the employer, justice to the employee, and justice to the public. If there be coddling of any one or a denial of equity to any one, the structure becomes unstable and liable to fall, and in that crash will go the interests of all.

Engineers and employers, the long-sought prize of ideal industrial relations is already within your grasp, but only by eternal vigilance can it be retained, for in this changing world, "Time makes ancient good uncouth."

When we fully realize that industrial relations are a major and not an incidental problem of production and that the employee's coöperation, welfare, self-respect, ways of thinking, and humors are major ingredients of success, and when we respect and use them accordingly, then we may visualize on our shores another statue of gigantic proportions, typifying America lighting the way to industrial freedom, prosperity, and peace.

The Bussey Process of Low-Temperature Distillation

THE process of low-temperature coal distillation covered by the Bussey patents is perhaps the simplest in conception of the many similar processes now under experimentation or attempted development.

It consists literally of maintaining combustion of a mixture of air and gas in the lower end of a vertical column of coal, which is confined within an air-tight, brick-lined stack, and in removing the consequent products of combustion together with the evolved gases from the top of the stack by drawing or forcing them through the superimposed mass of coal. The devolatilized carbon residue is removed from the base of the stack as formed, and fresh raw material in equal volume added to the top of the column as the charge settles, due to the action of gravity.

The design of the retort is comparatively simple, and, compared to the retorts used by many other processes, relatively inexpensive.

As the process demands the maintenance of a vacuum at the top and a pressure at the base of the apparatus, they are equipped with a specially designed double feed hopper fitted with interlocking valves operated by hydraulic cylinders on top, and a similar arrangement of double discharge hoppers below the retorts.

In normal operation the retort chamber is kept completely filled with coal at all times, the charge being supported on a rectangular floor or grate below the base. This grate is hollow and divided into sections through which the air and gas and steam necessary for the operation are admitted, and is adjustable as to its vertical position in relation to the base of the retort.

Above the grate in the discharge mechanism, which consists of a hollow water-cooled cast-steel cutter bar having a slow reciprocating movement at right angles to the grate's longest dimension, and is actuated by a screw mechanism driven by a small motor. The action of this bar pushes the portion of the charge immediately above the grate off of the opposite side of the grate from which it enters, and after traveling completely across, reverses and pushes the next cut off the opposite side of the grate. Its speed may be varied to suit the desired rate of operation.

The carbon residue discharged, falls into the first of the air-tight hoppers below, where it is quenched with exhaust steam—supplemented when necessary by a water spray.

The cycle of operation is as follows: The mechanism operating the cutter bar that discharges the retort is set in motion and as it completes its first movement across the grate it operates the mechanism controlling the operation of the discharge valve on the upper feed-hopper to which it is connected, and causes this valve to open and allows the coal to fill the lower feed hopper. This valve then automatically closes and locks shut. The cutter bar then reverses its direction of travel and as it completes its return stroke it causes the valve on the lower feed hopper to open and allows the coal to fill the retort, after which this valve also automatically closes and locks shut. Provision has been made for separate manual operation of these feed valves if desired, but the mechanism is so arranged that only one valve can be opened at a time, and both valves automatically close if not held open. This is a necessary precaution to take because of the vacuum normally maintained on the top of the retort.

The carbon residue discharged from the base falls into the first of the discharge hoppers where it is quenched as received, and when a sufficient quantity has accumulated it is dropped to the lower discharge hopper, and from that to the conveyor that carries the coke to the screening plant.

The control of the operation is not difficult, the operator's chief duties being that of watching the temperatures and pressures as indicated and recorded by the thermometers, pyrometers, and gages placed at critical points on the retort, and noting through observation ports the condition and temperature of the combustion zone near the base.

Control is maintained by varying the suction at the top, the pressure at the base, and by the amount of air, gas, and steam admitted through the grate, and by varying the rate of operation of the discharge mechanism. By the proper manipulation of these factors a graduated temperature from the bottom to the top of the retort can be maintained as desired.

While the design and operation of the retorts present no unusually difficult problems, the reactions within the column of coal are extremely complex and as yet little understood.

Our investigations to date indicate that the distillation may be considered as divided into three separate stages which take place in three separate zones, the first stage being that in which the incoming coal is heated by the passage through it of the evolved gases from below to about 300 deg. fahr. The mass of coal becomes considerably saturated with condensed oils in this zone, and these oils are constantly returned with the advancing coal toward the source of heat to be vaporized and again advanced toward the gas outlet.

The heavier portions undoubtedly fall with coal into the second stage or distillation zone, which may be considered as that portion of the retort in which the temperature range is between 300 and 900 deg. fahr. In this zone the charge is in a somewhat pasty mass thoroughly saturated with condensed oils returned from above, the lighter portions of which are vaporized and join the gases evolved from the coal in their upward sweep through the superimposed portion of the charge. Considerable amounts of the heavier portions or pitches from these oils undoubtedly join and fuse into the mass of carbon residue, and eventually pass through the combustion zone and finally out of the retort as pitch coke incorporated in the mass.

The third stage is that of hardening or setting the carbon residue and lowering its volatile content to the desired point. This takes place in the last or combustion zone, in which the gas and air are burned to supply the necessary heat to carry on the process. Considerable carbon monoxide and hydrogen are produced in this zone by the action of the steam introduced through the incandescent carbon mass.

From the results obtained while operating the retorts on 34 different coals we have processed to date, we can say that the average yield of carbon residue has equaled the percentage of fixed carbon plus the ash in the coal charged. That the yield of tar oils has varied from a minimum of 15 gal. to a maximum of 35 gal. per ton of bituminous coal charged, and that a yield of approximately 25 gal. can be expected for any fair grade of high-volatile bituminous coal. The cannel coals gave oil yields of 50 gal. to 110 gal. per ton of coal charged, but the oils were markedly different from those obtained from the bituminous coals. The ammonia yield from all coals was so small that its attempted recovery would be unprofitable. The gas yield varied from 20,000 to 30,000 cu. ft. per ton of coal charged, the volume varying slightly with different coals but being subject to a very large variation when change in methods of retort operation or control were made. The B.t.u. content of the gas averaged about 250 when the retorts were functioning normally.—Richard B. Parker in a paper read at the International Conference on Bituminous Coal, Pittsburgh, Pa., November 15 to 18, 1926.

Accuracy of the V-Notch-Weir Method of Measurement

BY D. ROBERT YARNALL,[1] PHILADELPHIA, PA.

The paper presents the results of tests made on a V-notch weir tank having a capacity of one million pounds of water per hour in which the accuracy was guaranteed to be within 1/2 of 1 per cent. The tests reported were carried out at the University of Pennsylvania. The details of the weir tank, the notches, and hook gage used, and the arrangement of the calibrating apparatus are described. The results are plotted and compared with those obtained by James Barr, published in "Engineering" in 1910.

IN 1912 at the annual meeting of the Society the author presented a paper[2] entitled The V-Notch Weir Method of Measurement, and now after fourteen years of further experience with V-notch weirs, it seems appropriate to present a second paper, which will have to do more particularly with the degree of accuracy which can be counted upon when using this method of measuring fluids.

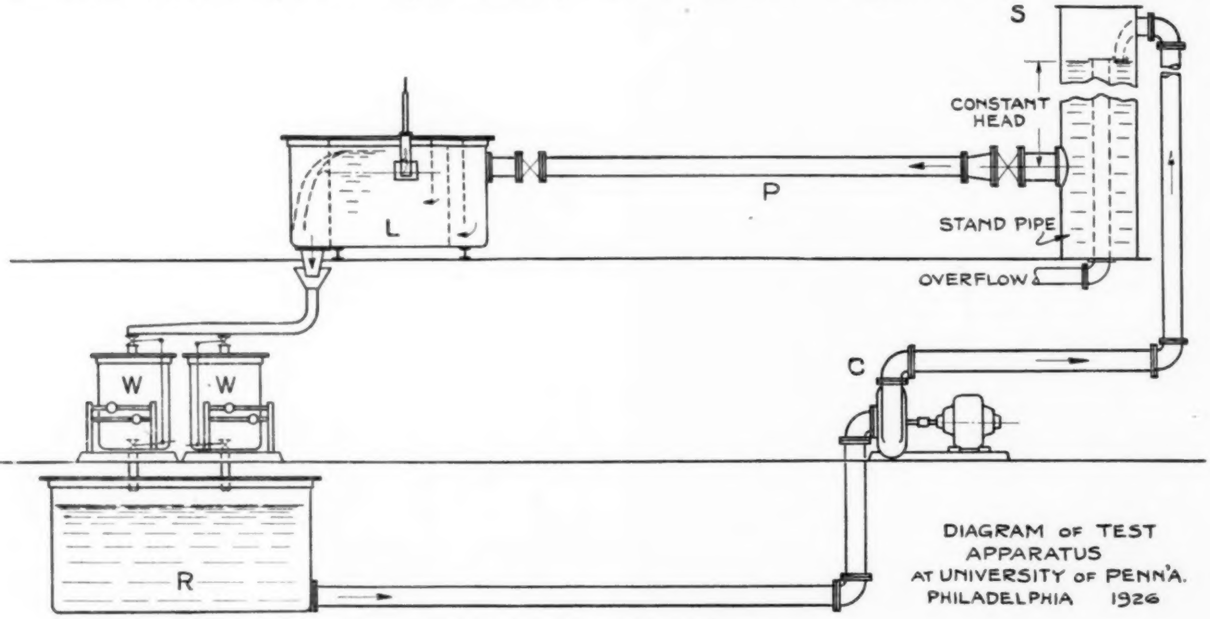


FIG. 1 DIAGRAM OF TEST APPARATUS

OBJECT OF TEST

We recently had occasion to build for the new Richmond Station of the Philadelphia Electric Company a V-notch meter with a maximum capacity of a million pounds per hour. This meter was to be used as a standard piece of testing apparatus for calibrating orifice and other types of meters, which are used for measuring various rates of flow in this station. As we were obliged to guarantee accuracies of this meter within 1/2 of 1 per cent over its entire range, whether using full 90-deg. weir plates or fractions thereof, it seemed advisable to make a special calibration of it. The Civil Engineering Department of the University of Pennsylvania kindly placed at our disposal their hydraulic laboratory for making the tests.

The paper deals with these tests, therefore, and it is hoped that the interesting results obtained may be of value to engineers, who may have occasion to use this method of measurement.

PERSONNEL

Acknowledgment is made to those who were instrumental in carrying through the investigation: Prof. W. S. Pardoe, of the University of Pennsylvania, F. G. Ely, test engineer of the Philadelphia Electric Company, and A. L. Aicher, chief draftsman of the Yarnall-Waring Company; it is through the patience and painstaking work of these men that the highly satisfactory results shown in this paper were obtained.

DESCRIPTION

Fig. 1 shows diagrammatically the apparatus used in making the tests and the arrangement. On account of the design of the standpipe *S*, which was located on the floor of the hydraulic laboratory, we were able to maintain constant heads at all times on the inlet of the meter.

On this same floor was placed a large V-notch meter tank *L*, as shown, which was connected by means of a horizontal pipe *P* to the standpipe, this horizontal pipe having two gate valves for throttling the rate of flow. As a matter of fact, the gate valve near the V-notch tank was left open, except for regulating the lower rates of flow—8 in. head and below.

The V-notch-meter tank discharged directly into a small hoppered flume, which in turn discharged into the weighing tanks *W*, shown on the floor below. These in turn discharged into the concrete reservoir *R* under the laboratory.

The water was circulated by means of motor-driven centrifugal pump *C*.

WEIGHING TANKS

The weighing tanks in the laboratory are conveniently arranged, so that even at the maximum rate of flow, of one million pounds per hour, no difficulty was found in accurately measuring the water in each tank in turn. Fig. 2 shows in detail the construction of the weighing tanks; and also shows the lever on the right of the weighing scale, which enabled the operator to discharge and fill the tank, since this lever controlled both the discharge valve and the inlet valve.

The accuracy of the weighing tanks with scales had been previously determined by means of a separate calibration.

METER TANK

Fig. 3 gives in some detail the construction of the tank of the V-notch meter, which was the subject of this investigation. It

[1] Yarnall-Waring Company. Mem. A.S.M.E.

[2] See Trans., vol. 39 (1912), p. 1055.

Contributed by the Power Division and presented at the Annual Meeting, New York, December 6 to 9, 1926, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. All papers are subject to revision.

will be noticed that the tank measures 108 in. long, 72 in. wide, by 60 in. deep, these dimensions being adequate for a 15-in. 90-deg. V-notch weir having a maximum capacity of one million pounds per hour.

Triple System of Baffling

Many engineers have the impression that in order to obtain reliable accuracy in weir measurements, a long flume or approach chamber must be provided, in order to smooth out the lines of flow and insure a uniform velocity of approach, as well as to obtain a dependable still water surface from which to measure the head. We have found from eighteen years of experience with this method of measurement that if baffle plates are carefully designed it is quite possible in a comparatively short tank to handle relatively large volumes of water without serious disturbance of the water surface in the approach chamber. In modern, rather condensed power stations the advantages of this design are obvious. In the meter here shown, we believe the baffling system is about as satisfactory as one could desire. It will be noticed that opposite the inlet X is provided a vertical baffle plate, which runs down to within 12 in. of the bottom of the tank, the opening extending across the entire (72 in.) width of the tank. Eight inches in front of this first baffle A-A is a second vertical baffle B-B, which is perforated over its entire surface, and which extends almost to the cover of the tank. Then 8 in. in front of this second perforated baffle is a third baffle C-C, which extends down from the cover plate about one-half the depth of the tank.

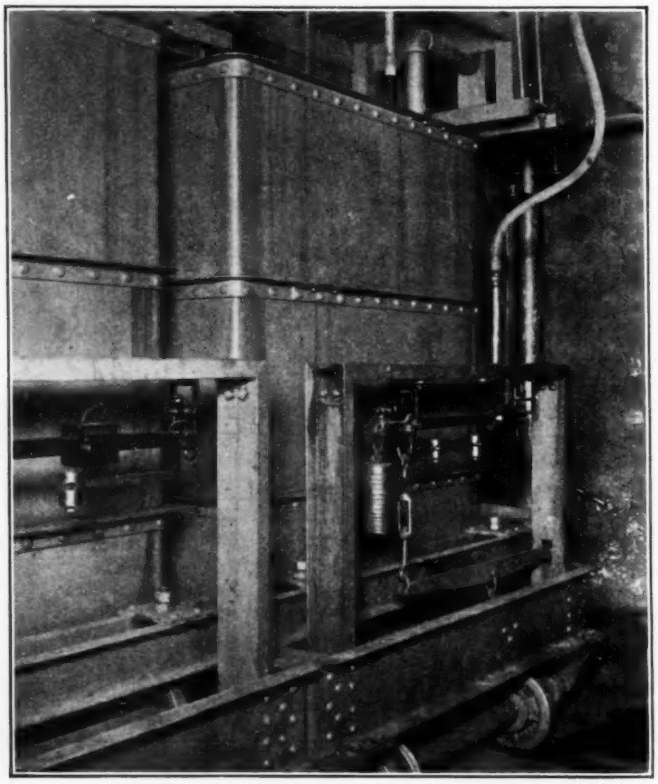


Fig. 2 Weighing Tanks

This "triple system" of baffles is so designed as to produce a gradually decreasing velocity of flow of the water from the inlet X to the approach chamber. These velocities are plotted on the diagram shown in Fig. 5, and the results obtained with this system are so satisfactory that on the water surface of the approach chamber, even at the rate of flow of one million pounds per hour, there was practically no disturbance of the water surface, so that most accurate hook-gage readings were possible.

V-Notches

Details of the four sharp-edged V-notch weir plates (actually measuring 1/32-in. wide) used for these tests are shown in Fig. 4. The outlet of the tank at Y, as shown, discharges directly into the weighing system below.

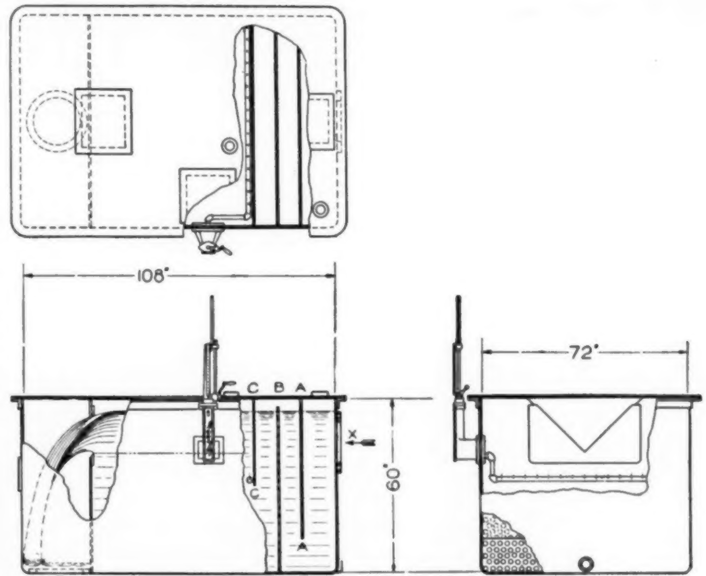


Fig. 3 The V-Notch Weir Tank

Hook Gage

As very great accuracy in the reading of the head was required, for such a calibration a special hook gage, shown in Fig. 6, was designed and built. This hook gage was mounted as shown on the side of the weir chamber just at the zero level of the weir. It is built in the form of a "bay window" and bolted to the side of the steel tank. The front of the projecting casting is of glass, so that

TABLE 1 RESULTS OF V-NOTCH WEIR TESTS

Date	Test No.	V Notch	Water weighed, lb.	Time period min.	Time period sec.	Water, lb. per hr.	Head, in.	Coefficient
3/17/26	18	Full	134510	8	30.6	948360	14.814	0.30017
3/17/26	19	Full	137355	8	28.2	973010	14.9855	0.29924
3/18/26	20	Full	145450	9	09.8	952380	14.8671	0.29878
3/18/26	21	Full	150005	9	08.7	984186	15.083	0.2978
3/18/26	22	Full	93415	12	06.2	463080	11.1329	0.29936
3/18/26	23	Full	57250	12	03.2	284986	9.1605	0.3002
3/18/26	24	Full	131215	10	06.3	779100	13.718	0.2998
3/18/26	25	Full	179150	10	58.8	978975	15.0522	0.29775
3/18/26	26	Full	15000	14	17.2	62996	4.988	0.303085
3/19/26	27	Full	257505	16	29.7	936676	14.76	0.29919
3/19/26	28	Full	83170	15	21.7	324848	9.6574	0.29965
3/19/26	29	Full	151855	14	59	608100	12.439	0.29795
3/19/26	30	Full	121305	11	58.3	607955	12.429	0.29845
3/19/26	31	Full	166120	11	00.5	905425	14.5833	0.29805
3/20/26	33	Full	155895	15	01.2	622750	12.562	0.29768
3/20/26	34	Full	150395	14	29.5	622680	12.5597	0.29778
3/20/26	35	Full	31530	10	48.7	174976	7.5446	0.2992
3/20/26	36	Full	15000	10	08	88816	5.7462	0.3000
3/20/26	37	Full	31650	10	46.4	176267	7.5628	0.2996
3/20/26	38	Full	106555	16	08	396280	10.475	0.29833
3/23/26	39	Full	30750	12	12.8	151065	7.117	0.298875
3/23/26	40	Full	30685	12	22	148880	7.063	0.30022
3/23/26	41	Full	62245	15	45.6	236970	8.529	0.2981
3/23/26	42	Full	15000	9	46.4	92068	5.822	0.30102
3/23/26	43	Full	13000	16	30.9	47229	4.452	0.30192
3/23/26	44	Full	15000	12	06	74378	5.3364	0.302275
3/23/26	45	Full	8500	12	26.4	40697	4.203	0.302645
3/24/26	46	1/2 90	5000	13	41.3	21917	4.316	0.15141
3/24/26	47	1/2 90	14000	11	47.4	71247	6.9177	0.15133
3/24/26	48	1/2 90	117800	16	01.8	440930	14.440	0.14877
3/24/26	49	1/2 90	83010	18	08.2	274613	11.9455	0.14887
3/24/26	50	1/2 90	28780	12	03.3	143242	9.1876	0.14967
3/25/26	51	1/2 90	106220	16	09.3	394500	13.8196	0.14858
3/25/26	52	1/2 90	53580	12	12.6	263290	11.7412	0.14901
3/25/26	53	1/2 90	124385	15	20.9	486250	15.0315	0.1484
3/25/26	54	1/2 90	30615	11	55.3	154080	9.469	0.1493
3/25/26	55	1/2 90	15000	12	29.3	72067	6.9741	0.150
3/25/26	56	1/2 90	15000	11	26.8	78625	7.2154	0.15031
3/25/26	57	1/2 90	6000	11	48.3	30495	4.9378	0.15048
3/26/26	58	1/4 90	15000	3	55.3	229500	14.737	0.07359
3/26/26	59	1/4 90	61840	16	21.8	226753	14.6947	0.07324
3/26/26	60	1/4 90	30420	14	09.7	128880	11.688	0.07376
3/26/26	61	1/4 90	30790	16	04.7	114900	11.171	0.07365
3/26/26	62	1/4 90	15000	13	54.3	64725	8.8606	0.074045
3/26/26	63	1/4 90	8000	10	51.8	44186	7.60	0.07419
3/26/26	64	1/4 90	4500	17	18.2	15604	4.964	0.075985
3/26/26	65	1/4 90	3000	15	20.2	11737	4.442	0.07546
3/27/26	66	1/8 90	15000	7	22.5	122033	15.131	0.036635
3/27/26	67	1/8 90	15000	8	16.3	108805	14.395	0.037
3/27/26	68	1/8 90	15000	8	00.2	112453	14.625	0.036755
3/27/26	69	1/8 90	11000	11	45.2	56154	11.033	0.03713
3/27/26	70	1/8 90	11000	10	42.2	61663	11.478	0.036935
3/27/26	71	1/8 90	3500	15	41.8	13379	6.1	0.03892
3/27/26	72	1/8 90	3500	11	10.9	18780	7.0237	0.038405
4/7/26	73	1/8 90	2000	12	36.1	9523	5.2738	0.03986
4/7/26	74	1/8 90	2500	11	26.5	13110	6.02	0.039416
4/7/26	75	1/8 90	2500	11	35.8	12935	5.9846	0.03947
4/7/26	76	1/8 90	6000	10	30.2	34275	8.9804	0.037915
4/7/26	77	1/8 90	6000	12	43	28310	8.3043	0.038085
4/7/26	78	1/8 90	7500	9	21.1	48119	10.827	0.03754
4/7/26	79	1/8 90	10000	7	59.6	75062	12.390	0.037072

the hook-gage position can be conveniently observed, as it is moved up and down to meet the water level by means of the small hand-operated crank, shown in Fig. 6. A vernier is attached to the movable rack and passes in front of the vertical scale in such a position as to be very easily read by the operator standing in front of the hook gage. The permanent zero adjustment indicator at the bottom of the bay window is clearly shown in Fig. 6.

In order to obtain a more perfect still water surface in the hook-gage chamber, a flange was bolted across the inlet of the bay window, to which was attached a perforated $1^1/_4$-in. pipe, as shown in Fig. 3. This pipe extended across the tank and was attached to and just above the bottom of baffle plate *C*, about 6 in. below the zero level of the meter.

In making zero adjustments before each test a hook gage, furnished by the University, was used as an auxiliary for setting the hook gage attached to the weir tank.

The cover plate of the tank was conveniently provided with three manholes, one over the inlet, one adjacent to the hook gage and one over the V-notch weir plate, so that during the tests, by means of electric lights placed just under the cover inside the tank, it was quite easy to observe the conditions of flow. These manholes also afforded means of making zero adjustments.

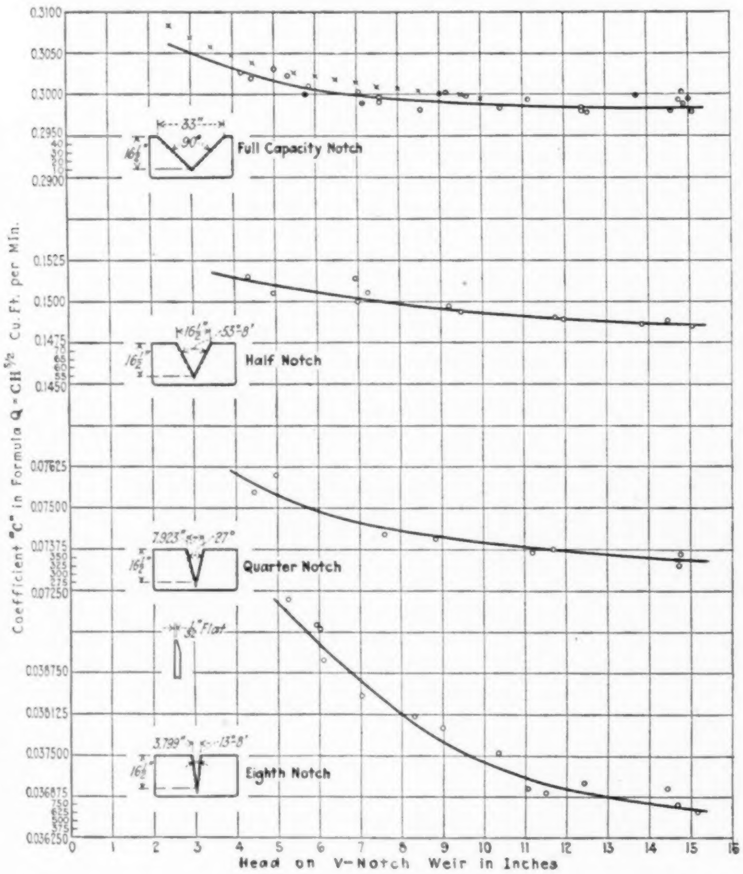


FIG. 4 RESULTS OF TESTS—COEFFICIENTS FOR THE VARIOUS NOTCHES
(The crosses near upper curve indicate values obtained by James Barr. See *Engineering*, April 8 and 15 and Oct. 28, 1910.)

TEST DATA

In the experiments with the V-notch meter under discussion there were actually seventy-nine complete tests made, covering about a month's work in actual time consumed. These tests were made to check the accuracy of the coefficients of discharge used in the regular V-notch-weir formula:

$$Q = \text{Coefficient} \times H^{5/2}$$

in which Q equals the quantity in cubic feet per minute and H equals head in inches.

Four complete series of tests were made, the first series on the full-capacity 90-deg. V-notch, the second series on the "$^1/_2$ notch," the third series on the "$^1/_4$ notch" and the fourth series on the "$^1/_8$ notch." The exact dimensions of the notches tested are shown on Fig. 4.

Tests Nos. 1 to 17, inclusive, were used to perfect the apparatus and the method of conducting the tests. The results of these first tests, therefore, were not used in plotting the coefficient curves on Fig. 4.

Test No. 32 was an experiment to try out, at a high rate of flow, the method of controlling the head by means of the 12-in. gate valve in the inlet connection next to the meter tank. The result of this test also was not used in plotting the coefficient curve.

During the tests there was very little variation in temperature of the water used. Actual tests for the density per cubic foot

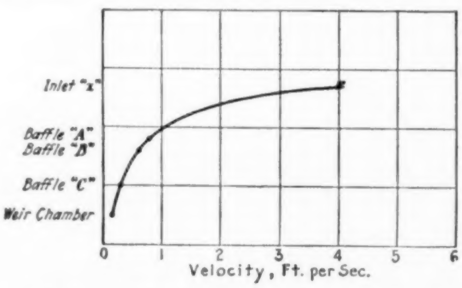


FIG. 5 VELOCITIES IN APPROACH CHAMBER OF WEIR TANK

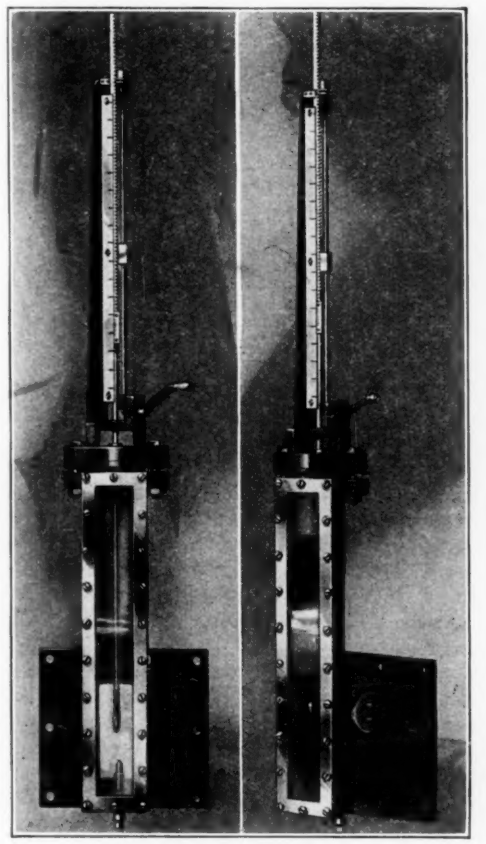


FIG. 6 THE HOOK GAGE

of the water were made by means of the U. S. Bureau of Standards weighing device, but there was no appreciable variation from the figure 62.34 lb. per cu. ft., which was used in all of the calculations.

In view of the convenience of the weighing apparatus described and shown in this paper, which is a part of the hydraulic-laboratory equipment of the University, it was possible to use the flying-start and flying-stop method; the time interval was obtained by an accurate stop watch, which was in the hands of Professor Pardoe, who actually operated the weighing-tank levers, and hence was in a position to control the interval of each test.

Head measurements were made with very great care, by means of the hook gage previously described. Two operators actually made the observations, one operator adjusting the hook gage at 15-sec. intervals, the other operator recording the head at the

same intervals. In this way many head readings were obtained and the average for the test used. It should be stated, however, that before any tests were made very careful adjustment of the inlet valve had been made to insure the head desired, and during the test there was, therefore, very little variation of this head.

Table 1 gives the actual results obtained.

Test Results

Fig. 4 shows graphically the results of the various tests made on the four different V-notch weir plates.

On the upper curve it will be noticed that we have indicated by means of crosses, the coefficients which were published by James Barr in *Engineering*, April 8 and 15 and October 28, 1910. Barr's tests were largely made on the lower rates of flow, but were made with the same 90-deg. V-notch weir plate as used in our tests. For some years past we have felt that his coefficient values were too high and it is interesting, therefore, to notice that our curve of

Fig. 7 The V-Notch Weir Tank in its Permanent Location

coefficients is slightly lower than his curve. To be sure, the difference is very small; nevertheless, we must seek to eliminate all factors which may introduce even slight errors in the measurement of rates of flow.

In the experiments which we have made we did not devote any time to determining the coefficients for the lower rates of flow, because there are already many data other than James Barr's covering this particular phase of the question.

Attention is called to the coefficient curves for the $^1/_2$ notch, $^1/_4$ notch, and $^1/_8$ notch, which were obtained in exactly the same way, and with the same apparatus as used for the tests on the full 90-deg. notch.

We have given in this paper exact information as to the dimensions of the four V-notch weir plates used, including the details of the section of the notch plates, in the hope that it may be of value to engineers who may desire to use this method of measurement.

Fig. 7 shows the V-notch meter used in these tests as it is installed in the testing laboratory of the new Richmond Station of the Philadelphia Electric Company, where it is used in the regular routine of station testing of orifice and other meters.

Conclusion

From the many tests which have been made with the apparatus described in this paper, we are convinced that by any one who uses the coefficients corresponding with any given head, shown by the curves in Fig. 4, accuracies within $^1/_2$ of 1 per cent may be obtained, because all of the points from which the curves were plotted are within this range of accuracy.

At some time we hope that it may be possible to carry these tests still further by establishing coefficients at rates of flow corresponding to 20-in. and even 24-in. head. We presume, however, that such coefficients will be only slightly different from the coefficients at 15-in. head, in view of the fact that all four of the curves seem to approach the horizontal at this point, as will be noted by observing Fig. 4.

Discussion

Written discussions of Mr. Yarnall's paper were submitted by W. S. Pardoe, A. G. Christie, and J. M. Spitzglass, and written comments were offered by V. M. Frost and C. C. Trump.

Concerning a point raised by Mr. Frost, Mr. Yarnall said that he purposely had not mentioned the translating device in the paper, because primarily the basis of any such device was the coefficient. He had been very anxious to give the engineering profession the advantage of the test described in the paper, which gave the coefficients for the higher head, and which so far as he knew had never heretofore been published. As to the translating device, he was a great believer in the type having a long curve wrapped around a drum. That curve could be simply plotted by using the coefficient values which were obtained in such tests as those he had described. He felt reasonably sure in saying that by using the very well-known Lea recording device, which had such a curve wrapped around a drum, accuracies could be obtained well within 1 per cent from zero up to the maximum capacity of the meter.

As to the relative merits of the orifice and venturi tube and the V-notch, each one had its field. There were very many cases of open flow where his company certainly was using them with confidence and could say that the V-notch-weir method of measurement had an accuracy well within 1 per cent. He would stress again the fact which Mr. Spitzglass and Professor Pardoe had mentioned in their discussions, namely, that those accuracies went over the entire range.

The curve of coefficients showed that it was flattening out, so that the coefficients for 20-, 24-, and 30-in. heads would probably lie along a horizontal line; and Mr. Yarnall hoped that the paper would stimulate some one with laboratory facilities to investigate the coefficients at these higher heads, for there certainly should be something published in that field.

Answering Professor Christie's question as to the way in which the zero had been established, he would say that in commercial practice it was usually established by having water up high and then gradually drawing it off until it came down to the zero pointer which had been mechanically set from the apex of the V-notch.

This method, however, had not been used in the tests set forth in the paper because it was not as accurate as one he would describe. In the first place, he had used a supplementary hook gage, placed not very far behind the V-notch. This had been leveled across mechanically, and the supplementary gage actually set at the apex of the V-notch. This had been done mechanically in order that they might be sure it was absolutely level. A reading had been taken on that scale. Then the weight had been dropped below the zero line and another reading taken. A reading had also been taken on the bay-window hook gage and the difference added to the reading on the bay-window hook gage. That, they felt, had been a more accurate method than to try to establish the water level at the exact apex of the V-notch.

Mr. Yarnall had nothing to say on the subject of viscosity of the liquid being metered. In commercial practice his company had to measure many viscous liquids for their clients, but they tried to establish fairly constant viscosity at the coil at the bottom of the weir tank, so that constant temperature was maintained. In those cases of volume measurement the instrument was calibrated in volume rather than in weight, and a correction for the changes in density and viscosity had to be made by the user.

Mr. Yarnall hoped that some other engineers might carry out the experiments involving viscosity which were suggested by Professor Christie and enlarged upon by Mr. Trump. He felt sure there was a definite relation between the coefficient of discharge and viscosity, but had no facts to present.

Regarding another point raised by Professor Christie—how close could the discharge water level come to the apex of the V-notch—he had found that in practice it was not safe to have the water level come nearer than the value of the head H. If it was a 14-in. discharge over a 90-deg. weir, that water level should not approach nearer than 14 in. He believed there had been some tests made where the water level had been brought very close to the apex of the V-notch, and it had been found that there was very little effect on the discharge. But he had no positive information on that point from his own tests.

The Effect of Water-Cooled Walls on Preheater Performance

Paper Presenting Data Supplementing Those Given by the Author in a Previous One Comparing the Performance of Several Types of Air Preheaters

By NEVIN E. FUNK,[1] PHILADELPHIA, PA.

THE data presented in this paper supplement those in the author's paper Comparative Performance of Air Preheaters,[2] read before The American Society of Mechanical Engineers at its Providence, R. I., meeting, May 3 to 6, 1926. These data were not available at the time the abovementioned paper was read.

In May information was presented on boiler unit No. 59 at the Richmond station regarding temperatures only, since the efficiency tests had not been completed. Particulars are now given regarding boiler No. 49, which is identical in every respect with No. 59, with the single exception of a steam-separating apparatus for measuring the amount of steam delivered by the Bailey water-cooled walls. In making comparisons with the previous paper, No. 49 can be substituted in relation to any of the other boilers for boiler No. 59. However, the temperatures obtained are quite different since increased experience in handling the preheated-air boilers with the Bailey wall installation permitted operation at higher CO_2 than was thought advisable during the tests when temperature readings were taken on boiler No. 59. This affects the temperature distribution throughout the boiler.

The cross-section and side elevation of boiler No. 49 at Richmond are the same as shown in Fig. 4 of the previous paper for boiler No. 59 at Richmond, the steam separator for the Bailey walls having no effect on the boiler performance.

The elevation of unit No. 7 at Chester was given in Fig. 3 of the previous paper. The performance of this boiler was unsatisfactory from an operating point of view due to serious trouble from burn-outs at the ashpit end of the stoker and the destructive effect of the furnace temperature on the brickwork. To correct this trouble Bailey water-cooled walls were installed in the bridgewall and the side walls as shown in Fig. 1 of this paper. No change, other than these walls, has been made in boiler No. 7 at Chester. All the succeeding data on boiler No. 7 with the Bailey wall installation will be referred to as No. 7-A tests. The data given for all the boilers in Table 1 of the previous paper remain unchanged, those for boiler No. 49 being the same as those for No. 59 there given, and No. 7 having 645 sq. ft. of surface in Bailey water walls in addition to the surfaces given in the table. Briefly, they are as follows.

		Heating Surface, Sq. Ft.				
Station	Boiler No.	Boiler	Superheater	Economizer	Preheater	Water wall
Chester	3	14,217	2,582	5,250	22,072	..
	7	14,217	2,582	...	64,960	645 (a)
Richmond	49	15,692	2,822	7,515	22,072	595

(a) In the 7-A tests.

There are no changes in the physical characteristics of the stoker or air preheater from those given in the May paper.

In Fig. 2 the author has plotted the efficiencies of boilers Nos. 49, 3, and 7 against thousands of pounds of dry coal burned per hour. The curves for the No. 3 and No. 7 boilers were given in Fig. 6 of the previous paper, but are duplicated in Fig. 2 for the purpose of comparing No. 49 with No. 3, and test No. 7-A with No. 7.

The air preheaters on boilers No. 3 and No. 49 are both of the B. & W. tubular type and have the same heating surface.

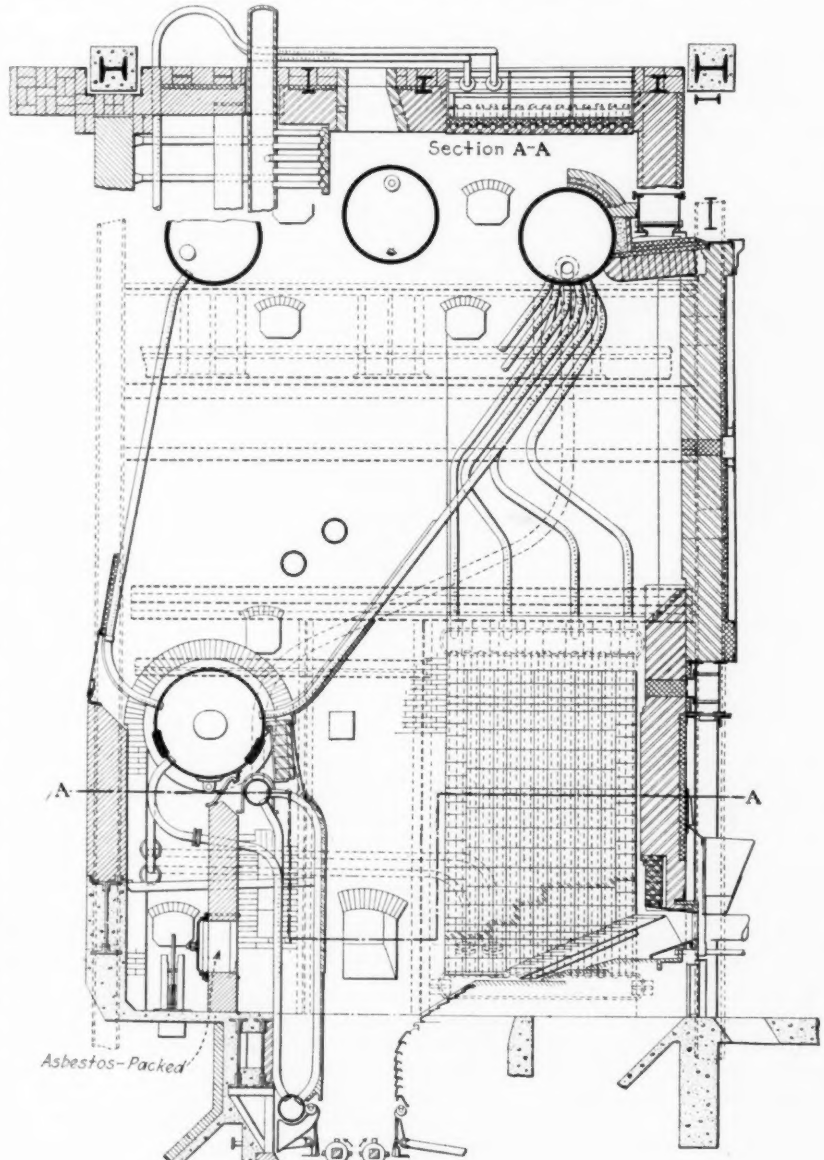


Fig. 1 Cross-Section of Boiler No. 7 at Chester Station After Installation of Water Wall

The economizer surface on boiler No. 49 is 43 per cent greater than on boiler No. 3. The superheater surface is 9 per cent greater on boiler No. 49 than on boiler No. 3, and the boiler surface of No. 49 is 10 per cent greater than that of No. 3. The boilers are of practically the same design with the exception of the Bailey wall installation on the bridgewalls and side walls of No. 49 which replace the firebrick walls and perforated carborundum air blocks installed in boiler No. 3 These differences in characteristics were given in Table 1 of the previous paper. The stoker serving

[1] Operating Engineer, Philadelphia Electric Co. Mem. A.S.M.E.

[2] Published in Mechanical Engineering, June, 1926, pp. 562–566.

Presented at a meeting of the Philadelphia Section of the A.S.M.E., Philadelphia, November 23, 1926.

boiler No. 49 is slightly longer than that serving boiler No. 3.

It will be noted that boiler No. 49 is practically 2 per cent higher in efficiency than boiler No. 3 throughout the range of the tests. The effect of the water-wall installation can be better determined, however, from the temperature changes throughout the boiler unit which are given in succeeding curves.

The tests listed as No. 7-A in Fig. 2 were made on boiler No. 7 after the brick and perforated carborundum air blocks had been removed and Bailey water-cooled walls installed in the bridge and side walls. It will be noted that while the increase in efficiency was only slightly over 1 per cent at low ratings, the efficiency differential was increased to about 5 per cent at a rating of 12,000 lb. of dry coal per hour.

In order to follow the performance of these boiler units as far as subdivision of the heat absorption is concerned, the flue-gas temperatures at the boiler outlet, economizer outlet, and preheater outlet have been plotted in Fig. 3. At a rating of 12,000 lb. of dry coal per hour it will be noted that the boiler outlet temperature for boiler No. 49 was 120 deg. below that for boiler No. 3. This reduction is due to increased boiler surface and the installation of Bailey walls on boiler No. 49. A definite allocation of the temperature reduction due to these two factors cannot be readily made, due to the better combustion obtained in the furnace with the Bailey wall installation in which it was possible to obtain higher CO_2 without the danger of CO loss.

Effect of Water Walls

The effect of the Bailey walls is more definitely shown in the difference between tests No. 7 and No. 7-A in Fig. 3. In this

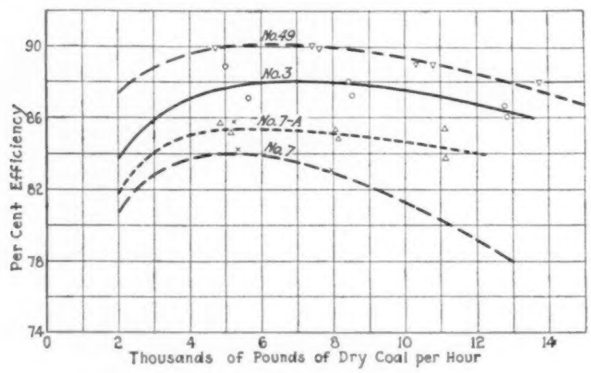


Fig. 2 Efficiencies Plotted Against Thousands of Pounds of Dry Coal Burned per Hour—Boilers Nos. 49, 3, and 7

$$\left(\text{Efficiency in per cent} = \frac{\text{Heat input to steam}}{\text{Heat in coal fired}} \times 100.\right)$$

case there was no other disturbing factor in making the comparison, and it is therefore safe to credit the Bailey wall installation with the reduction of 54 deg. in the boiler outlet temperature at the rating of 12,000 lb. of dry coal per hour.

As would be expected, the reduction in the outlet temperature of boiler No. 49 lowered the gas temperature at the outlet of the economizer. This reduction, however, was only a small percentage of that in the boiler outlet temperature, the heat absorbed by the economizer being greatly reduced due to the decrease in the temperature of the gases passing to the economizer.

The reduction in the economizer outlet temperature likewise affected the air-preheater outlet temperature to some extent, although the difference between the preheater outlet temperatures for boilers No. 49 and No. 3 is quite small. The decrease in stack losses is practically all accredited to the reduction in gas volume due to higher CO_2.

The reduction in the boiler outlet temperatures for test No. 7-A is reflected in the reduction in the preheater outlet temperature for the same test. The reduction in the preheater outlet temperature, however, is not as great as the reduction in the boiler outlet temperature because the preheater did not absorb as large a quantity of heat due to the lower initial temperature of the gases. Since the CO_2 was practically the same in both No. 7 and No. 7-A tests, better efficiency can be credited to the better heat absorption of the boiler and the Bailey walls as a unit.

The temperature change of the gas and air through the air preheaters has been plotted in Fig. 4 against the rate of boiler operation. It will be noted that the performances of air preheaters Nos. 3 and 49 are practically identical. The apparent performance of the air preheater on boiler No. 7 with and without the Bailey walls is quite different. There is some uncertainty in accounting for this difference. It is known that the leakage of

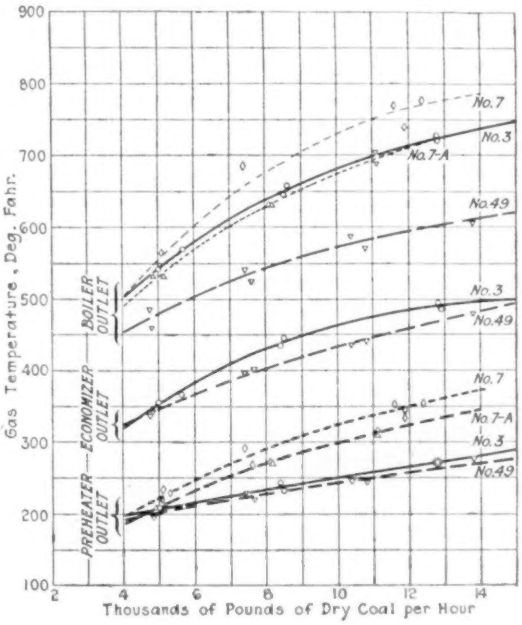


Fig. 3 Flue-Gas Temperatures at Boiler, Economizer, and Preheater Outlets Plotted Against Thousands of Pounds of Dry Coal Burned per Hour

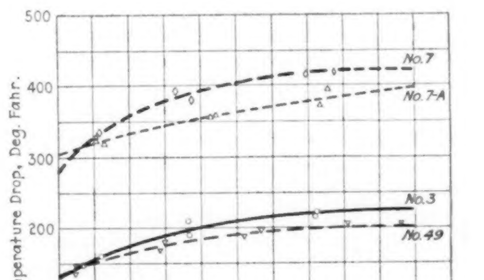


Fig. 4 Temperature Changes of Gas and Air Through the Air Preheater

cold air into the flue gas in test No. 7-A was somewhat greater than in test No. 7. This would reduce the measured flue-gas temperatures below the correct gas discharge temperature from the heater, which would, by subtraction, give an increased gas drop from the correct value. It is therefore possible that the difference in the actual gas temperature drop between No. 7 and No. 7-A should be greater than shown in Fig. 4, being more of the order of the difference plotted for the air temperature rise.

While there is the possibility of an error in the flue-gas temperature measurements, the air temperature measurements are correct, and for this reason the amount of heat returned to the boiler by the air preheater is in the direct ratio of the temperature rises plotted in Fig. 4. This reduction in preheated-air temperature is

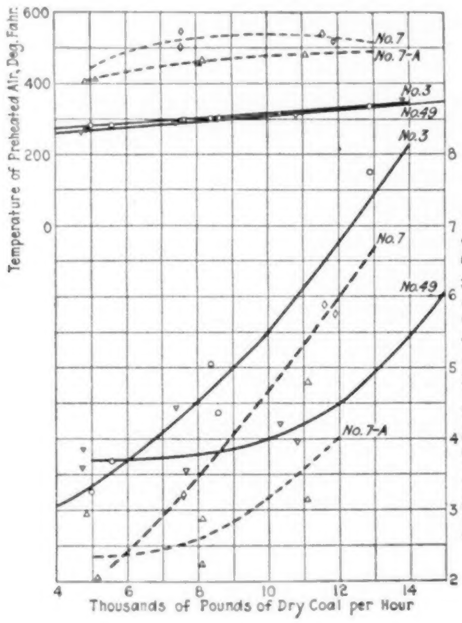


Fig. 5 Effect of Preheated Air on the Amount of Combustible in the Refuse

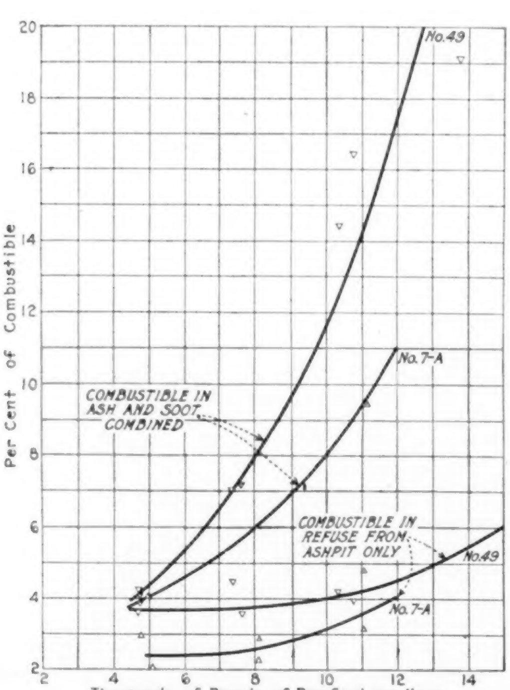


Fig. 6 Percentage of Combustible in Ashpit Refuse and Soot Plotted Against Thousands of Pounds of Coal Burned per Hour

due to the fact that there is less heat supplied to the air preheater because of the better heat absorption of the boiler and Bailey wall unit.

Preheated Air and Amount of Combustible in Refuse

The effect of preheated air on the amount of combustible in the refuse has been plotted in Fig. 5. Boilers Nos. 49 and 7-A, both with Bailey walls, show a marked reduction over No. 3 and No. 7 without water-cooled walls, indicating that the installation of these walls has effected a decided improvement in the combustion throughout the fuel bed. There might be some doubt as to the walls being directly responsible for this reduction in the No. 7 and No. 7-A tests, since the preheated-air temperature in No. 7 was higher than in No. 7-A and it was shown in the author's May paper on preheaters that an increased preheated-air temperature reduces the combustible in the refuse. This factor, however, is not present in the test of boilers Nos. 3 and 49 since the preheated-air temperatures were practically the same, and therefore the reduction in combustible in the refuse must be credited to the effect that the walls had on combustion.

The comparison of the combustible in the refuse, however, does not give a true picture of the loss due to unburned combustible matter. In Fig. 6 the author has plotted thousands of pounds of dry coal per hour burned as abscissas, and as ordinates the percentage of combustible in the refuse from the ashpit alone, with both the ashpit refuse as the 100 per cent base and the percentage of combustible in the ashpit plus the soot collected from the boiler with the ashpit refuse as the 100 per cent base. Attention is called to the fact that while the combustible in the refuse from the ashpit alone is very low, the combined combustible loss is as high as 20 per cent of the ash withdrawn from the ashpit.

Unfortunately in the test made without water-cooled walls this combustible loss in the soot in the boiler has been thrown into the

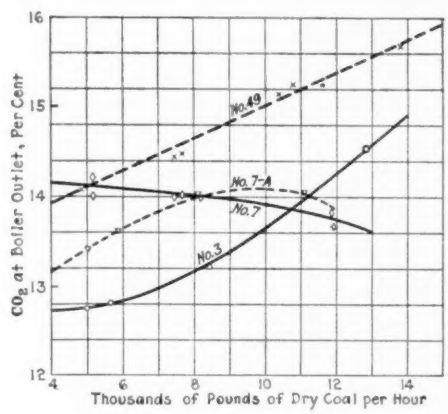


Fig. 7 Change in CO_2 at Boiler Outlet with Change in Rate of Driving

unaccounted-for losses in accordance with the A.S.M.E. Boiler Test Code, in which will be found a definite statement of how the unconsumed combustible in the refuse is to be calculated.

In all probability this matter of soot with the water-cooled walls would have been neglected in these tests had it not been discovered that large quantities of soot were made when the boilers were first started with the walls unslagged. These quantities were so large as to require daily cleaning from the soot chambers, and of course drew immediate attention to the amount of soot produced. As the walls became coated with slag the amount of soot production was reduced tremendously. It was found that after there were three inches or more of slag on the walls, the soot production reached a minimum. All tests that were made prior to the formation of three inches of slag were discarded and have not been used in this discussion, so that the information presented is on a uniform basis. The author has arranged, due to this experience, to have a complete record of the soot formation obtained on all future boiler tests both with and without water-cooled walls.

That increased preheated-air temperature reduces the amount of loss in unburned combustible matter is interestingly corroborated by the fact that the preheated-air temperature of boiler No. 7-A averaged 150 deg. higher than that of boiler No. 49, and the total combustible loss in the soot and ash combined at high rates of operation was approximately 6 per cent less on boiler No. 7 than on No. 49.

In the previous paper a description was given of the care taken in obtaining accurate ash samples by grinding the entire quantity of refuse from the pit. However, when the quantities of combustible in the refuse become as small as 3 or 4 per cent, it is very difficult to obtain sufficient accuracy with variations in rating to justify an accurate curve of performance. For this reason the curves plotted for No. 49 and No. 7-A to show the combustible in

the refuse alone must be considered as mere trends and not as definitely accurate quantities, although they were the accurate analyses made of the ash samples obtained; the difficulty lies in obtaining an accurate ash sample. The effect of a 20 per cent error in the combustible in the refuse at these low values would cause no error in the boiler efficiency, but would affect the unaccounted-for losses by approximately $1^1/_2$ per cent of those losses, and is not a serious factor in the heat balance of the boiler test.

To complete the information on these later tests for comparisons that the reader may desire to make with the tests given in the previous paper, the author has plotted in Fig. 7 the CO_2 at the boiler outlet against thousands of pounds of dry coal per hour.

An interesting comparison of the distribution of losses on boiler No. 7 with and without water-cooled furnace walls is given in Fig. 8. The losses in B.t.u. per hour for boiler No. 7 without the Bailey walls have been plotted as abscissas against the B.t.u. losses in boiler No. 7-A, with the Bailey walls, as ordinates for the same input to each boiler. The inputs were varied from low to high ratings. The 45-deg. reference line would indicate that the distribution of losses was the same for boilers with and without the Bailey walls. Where any of the curves lie below this 45-deg. reference line they show a decrease in these losses.

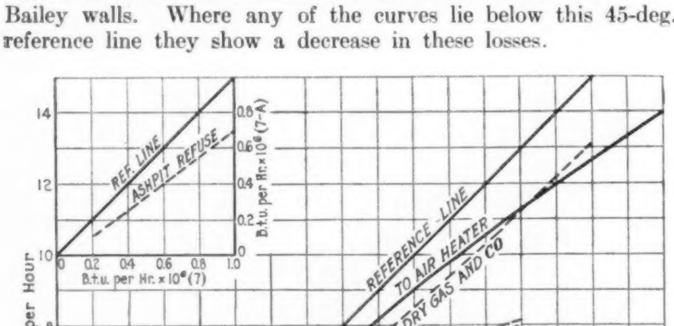


FIG. 8 DISTRIBUTION OF LOSSES IN BOILER WITH AND WITHOUT WATER-COOLED FURNACE WALLS

The losses have all been plotted as dotted lines. The heat transferred to the air by the air preheater has been shown as a solid line. The ratio of loss in the ashpit refuse has been plotted to a larger scale in the upper left-hand corner of the figure. Attention is called to the fact that the loss in the refuse with the Bailey walls is lower than before the walls were installed.

Operating experience would lead to the belief that a larger amount of soot is produced in a boiler with water-cooled walls than in one without them. This loss in unburned carbon in the soot is contained in the unaccounted-for loss, and in spite of this possible increase in soot loss, the unaccounted-for losses, after the water-cooled walls have been installed, are less than prior to the installation, showing that if there is an increased loss in the soot it is more than counterbalanced by the reduction in radiation losses.

The loss in the dry gas and CO has been reduced by increase in CO_2 as shown in Fig. 7. The loss due to moisture is probably the same in both cases, and the variation shown is due to the slight variation in moisture and hydrogen in the fuel. It will be noted that the energy transferred to the air by the preheater is less over the entire range of rating for the unit after the Bailey walls were installed. This is to be expected on account of the increased absorption in the boiler and furnace as shown from the gas temperatures plotted in Fig. 3.

Measurements were made of the total amount of steam generated in the Bailey walls. This quantity has been plotted against per cent of boiler rating in Fig. 9, together with the percentage of the total heat input to the furnace which this steam output represents. The curves in Fig. 9 were obtained with a formation of three inches or a somewhat greater depth of slag on the water-cooled walls, the limitation of slag thickness being between three and four inches.

Heat-transfer rates have been plotted in Fig. 10. Curves B and C show the rate of B.t.u. transfer per hour per square foot of water-wall surface for variation in boiler rating. Curve A, which was obtained with the unslagged walls, has been plotted as an indication of the increased heat transfer with this condition. However, the measurements are somewhat in doubt since the slag formation was varying, and this curve of wall performance is given merely to show the trend of the heat absorption in the walls from the point

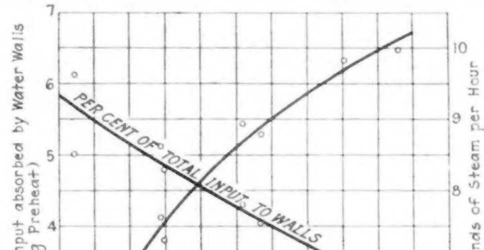


FIG. 9 TOTAL AMOUNT OF STEAM GENERATED IN THE BAILEY WALLS AND THE PERCENTAGE OF TOTAL HEAT INPUT TO THE FURNACE IT REPRESENTS, PLOTTED AGAINST PER CENT OF BOILER RATING

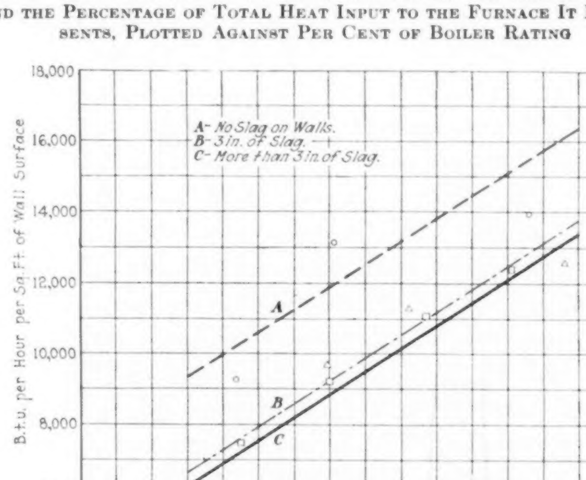


FIG. 10 HEAT TRANSFER THROUGH BAILEY WALLS

of initial operation until the normal amount of slag formation has occurred.

It is believed that the data presented herewith may be of some value in comparing the design of water-wall surface to boiler surface, and air-preheater surface to boiler surface. It must be remembered that the exact values given apply to the units as installed and that there are so many variables affecting the individual operation of each element of the unit that extreme care must be taken in applying the information. The data are of value in indicating the general trend in the performance of these various pieces of equipment. The absolute values for each individual piece might be considerably changed by merely baffling the boilers differently, although in all probability this would have less effect on the performance of the Bailey wall than on the remainder of the boiler unit.

The author desires to take this opportunity to publicly thank Mr. H. W. Phillips of The Philadelphia Electric Company for his able assistance in preparing the data contained in the paper.

Applications of Radio in Air Navigation

Radiotelephone Communication—The Double-Beam Directive Beacon—Marker Beacons—Field Localizers—Direction Finders—Landing Altimeters, Etc.

By J. H. DELLINGER,[1] WASHINGTON, D. C.

RADIO is being used for many purposes, some of them more appropriate than others. The major uses for which it is appropriate include broadcasting, transoceanic telegraphy and telephony, communication with ships at sea, and communication with aircraft. The applications to aircraft are now going on with great rapidity and are similar in principle to the marine uses but very different in the actual working out. Both for marine vessels and for aircraft, radio provides the ideal means of exchanging messages, of providing navigational aids, and of remote control. There is practically no field of usefulness for remote control except in military practice, and it will be left out of consideration in this discussion.

In its important functions of carrying messages and of providing aids to navigation, there are clear lines of differentiation in the evolution of radio for marine and for air use. These depend largely on the essential differences in speed, size, and weight limitation. Another difference is the special problem of landing which the airplane offers. Whereas an airplane is a small, light, rapidly moving object, a marine vessel, from the radio viewpoint, is but little different from an island. It can carry any type and amount of radio apparatus, and can be as leisurely as it pleases in using it. Lighter-than-aircraft are intermediate between the airplane and marine vessel in their radio requirements. They can use any of the radio aids that an airplane can, and some of those adapted to marine vessels in addition. Airplanes are principally in view in this discussion, particularly because the problems which require attention at the present time arise out of the need of developing radio aids to air plane navigation on the existing and rapidly developing civil airways.

Radiotelephone Communication

It is generally agreed that the primary and most urgently needed application of radio in air navigation is simply that of communication. The great problem of the airplane at the present time is that of landing. The maintenance of communication so that the pilot, regardless of weather conditions, may be kept advised of suitable landing places, is the first requisite. Comparing airplane communication with that applicable to marine vessels, it may be stated that aircraft require telephony instead of telegraphy, and that the communication be at higher frequencies, and, generally speaking, over shorter distances than for marine vessels. The use of continuous-wave radiotelegraphy is inherently a more economical method of communication than radiotelephony, and is the natural means of communication for ships. This, however, requires the use of an operator trained in the telegraphic code. Most airplanes now have no crew other than the pilot, and this condition will doubtless be true for a long time to come. It is not to be expected that the pilot will also be a telegraph operator, and it therefore follows that radiotelephony rather than radiotelegraphy will be the system used on aircraft. Higher frequencies will be used than in marine communication because of the relatively small size of airplanes. It is inconvenient and undesirable to use long antennas on airplanes. Short antennas work most efficiently with high frequencies. It is therefore to be expected that relatively high frequencies will become standard for aircraft radiotelephony.

It was stated above that aircraft communication is characterized by shorter-distance work than marine communication. This is true both because of the weight limitation on transmitting or receiving apparatus carried on the airplane, and also because of the interference to reception produced by the airplane-engine ignition system. A shielding system can and should be used on all airplane engines which largely eliminates this interference, but the perfection of this shielding is limited by the additions to the total weight. It may be said, furthermore, that there is no good reason why great distances need to be covered in aircraft communication. Here we have an essential advantage over marine navigation. On the airways of the country radiotelephone transmitting and receiving stations can be placed at convenient and relatively short intervals. These will be advantageous for the aircraft, and incidentally such a system will be more economical than one of a very few

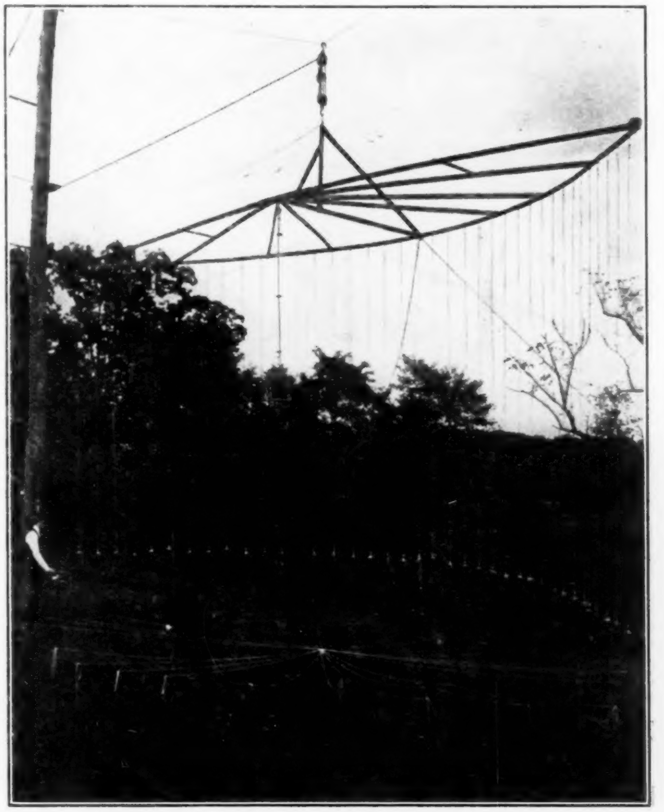


Fig. 1 Parabolic Reflector of Short Radio Waves

(This sends out a beam which might conceivably be adapted to guiding aircraft. The beam of radio waves is, however, not sharply defined like the light beam from a searchlight, and this method is not as promising as the double-beam directive beacon.)

stations of great power placed great distances apart. In this respect aircraft communication has an advantage over marine communication.

It is generally agreed that communication to the aircraft is much more important than communication in the other direction. It will add immeasurably to the peace of mind of the pilots and the safety of flying when all airplanes carry radio receiving sets and there is an adequate system of ground stations telephoning information as to weather, landing conditions, etc. As the airways develop and passenger carrying becomes more common, there will be an increasing use of radiotelephony from the aircraft as well. Two-way communication will of course be a great advance. There are a great variety of technical problems involved in this and all the other applications of radio to air navigation, some of them requiring research and engineering work yet to be undertaken. The author can do no more than mention a few of those concerned in the proper development of telephony to and from aircraft; these include the techique of shielding ignition systems, the choice of type of receiving sets, the type of power supply for transmitting sets, the type of power supply for transmitting sets, and the all-important problem of the assignment of frequencies.

[1] Chief of Radio Laboratory, Bureau of Standards.

Presented at a joint meeting of The American Society of Mechanical Engineers, the Aero Club of Pennsylvania, and the Engineers' Club of Philadelphia, Philadelphia, September 7, 1926.

The Directive Beacon

Besides solving the problem of communication with aircraft, it is obvious that radio furnishes an instrument of navigation. During clear weather and for flying below the clouds a pilot needs no navigational instrument other than his eyes, for he can see the

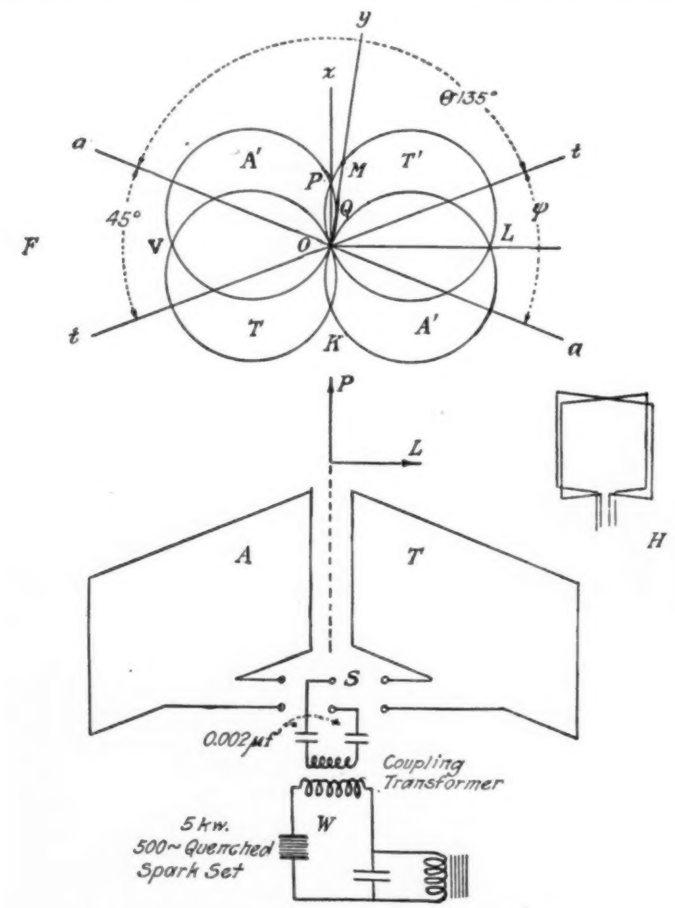


Fig. 2 Principle of the Double-Beam Directive Beacon

(In the upper part of diagram the A and T pairs of circles show in polar coördinates the relative intensities of radiation for each transmitting coil A and T in all directions. On the bisector OX the intensities from the two coils are equal.)

ground in the daytime and the airways will be provided with lights for night flying. When the ground is obscured by fog, however, or when the aviator wishes to fly at great elevations, radio is the only navigational aid available. In making use of the directional properties of radio there is a marked difference between the trend for air navigation and that for marine navigation. Marine vessels are finding the radio direction finder of the greatest assistance as an aid to navigation, particularly in fog, but there is little tendency to equip airplanes with direction finders. On account of the weight limitation it is highly desirable that means be provided to guide airplanes on a course without requiring that they carry any direction finder, or any apparatus other than the receiving set which will be carried for other purposes anyhow. This requirement is met by the directive radio beacon. The most promising beacon of this type, and the only one which has been developed into a practical form, is the double-beam directive beacon which was developed by the Bureau of Standards for the Army Air Service five years ago. This beacon sends out two directed radio beams, continuously transmitting on each of the two beams a characteristic signal. When near the axis of either beam the pilot listening to the signals with an ordinary receiving set hears the signals from that beam much louder than those from the other. Half-way between the two the signals from the two beams are heard with equal intensity, and an equisignal zone is thus marked out and provides a convenient and reliable means of flying a given course. A beacon of this type is in use at McCook Field, and in the form there used the signals in the two beams are so adjusted as to interlock when the aviator is on the equisignal zone; that is, in this zone a continuous dash is heard instead of a series of dots and dashes which are heard when off the zone.

It seems clear that this radio beacon will be used to mark the routes between landing fields. It is usable regardless of weather conditions. It assists in solving the problem of flying during poor visibility, as the flier can go above the poor-visibility level in flight. The beacon signals serve as well at high altitudes as low.

It is possible that this beacon method may be modified by providing a simple device which can be used with the receiving set on the aircraft, having a pointer which indicates visually the position of the aircraft on or off the course. It is understood that the aviators are satisfied to use the aural method, since the pilot has to wear a helmet anyway and since a helmet has been devised in which the presence of the ear phones adds no discomfort. In spite of this it

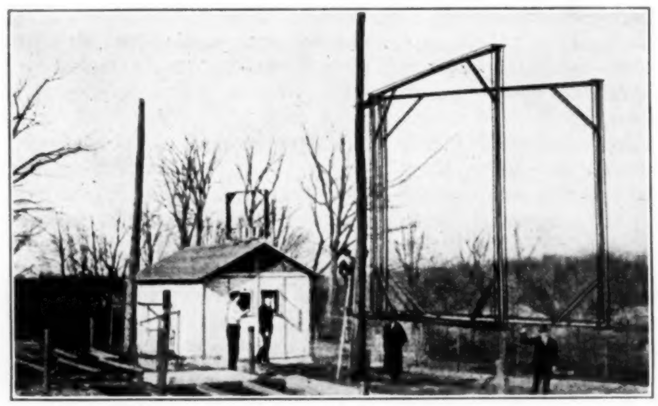


Fig. 3 Experimental Coil Antennas Supported on Pole in Original Experiments on Double-Beam Directive Beacon

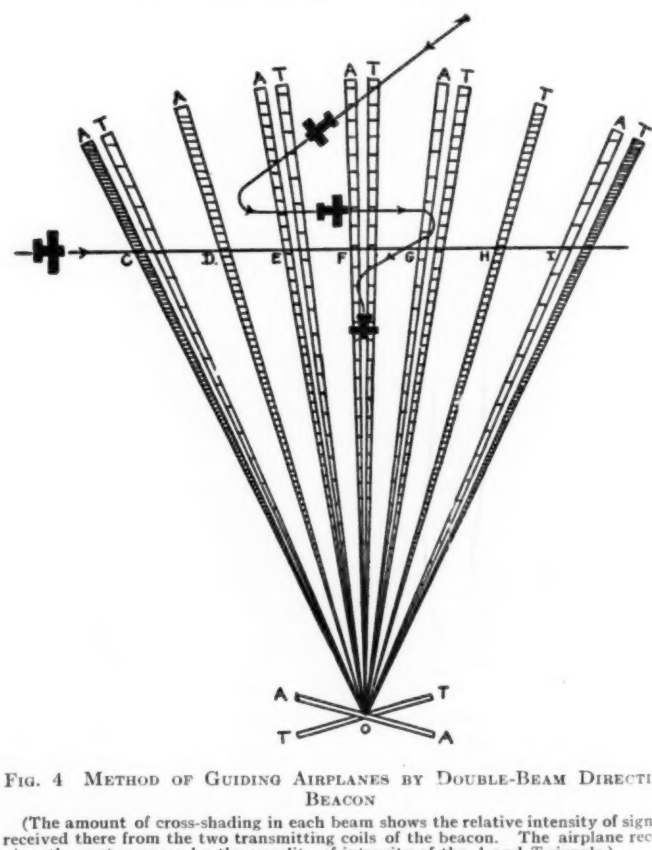


Fig. 4 Method of Guiding Airplanes by Double-Beam Directive Beacon

(The amount of cross-shading in each beam shows the relative intensity of signals received there from the two transmitting coils of the beacon. The airplane recognizes the center course by the equality of intensity of the A and T signals.)

may be that a visual indicator now under development would be a great improvement. In the aural method there is some difficulty in distinguishing the different types of signals on and off the equisignal zone because of the inevitable background of clicks and noise of various kinds. While a pilot would become skilled in the use of these signals, it nevertheless is a slight strain upon him, and if the

visual indicator is developed successfully it will tend to reduce the strain.

This radio beacon is undoubtedly practical, but a number of problems will arise when a large number of them are in use and when there is a necessity of marking out several courses radiating from a given airport or beacon station. The device can serve as a beacon for all directions by continuously rotating the equisignal zone and employing a stop watch on the aircraft, but this would be a complicated system and would be so much less simple in use that its utility is doubted. By rotating the equisignal zone in steps, however, setting it for brief periods successively on the several courses desired, a satisfactory service can probably be worked out. When there are many of them in use, it may be necessary to provide

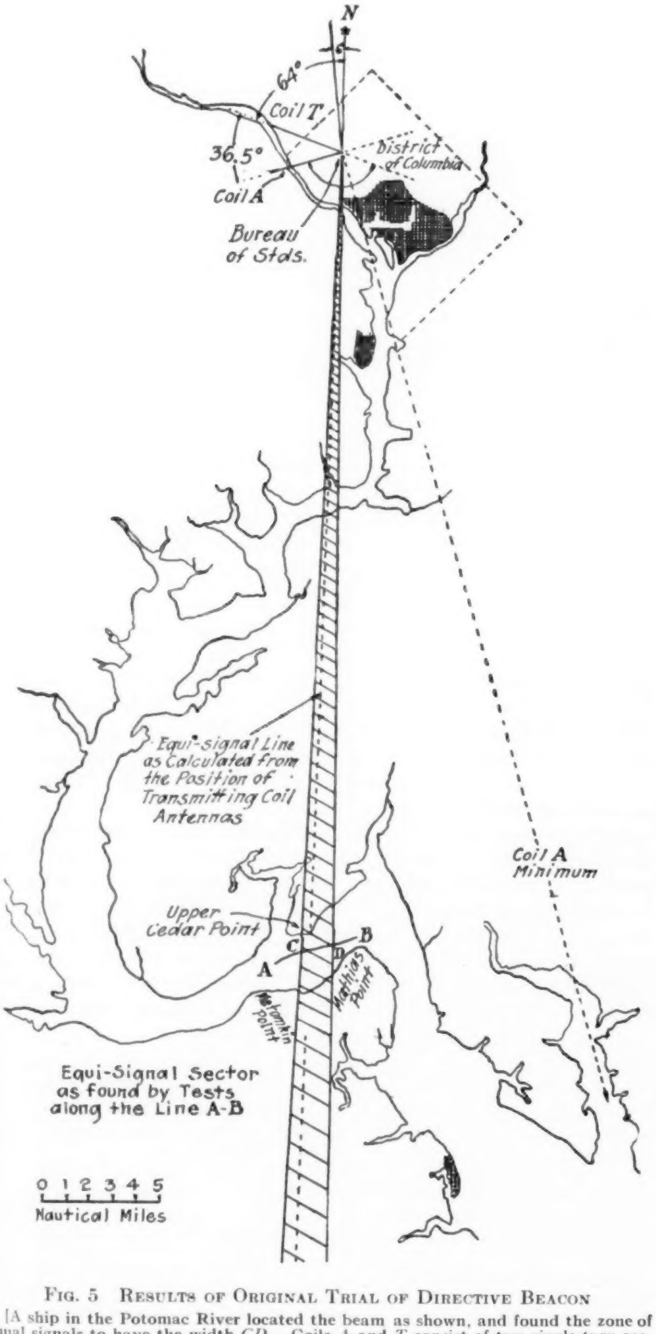


FIG. 5 RESULTS OF ORIGINAL TRIAL OF DIRECTIVE BEACON

[A ship in the Potomac River located the beam as shown, and found the zone of equal signals to have the width CD. Coils A and T consist of two single-turn rectangular coils 12.2 × 35.7 meters (40 × 150 ft.) crossed at an angle of 143.5 deg. Type of transmitter, 2-kw. 500-cycle quenched-spark; coil current, 9 amperes; wave frequency, 300 kc. (1000 m.)]

special means of recognizing the signals when set on different courses and those of different beacon installations. The limitations of radio, particularly the additions to interference made by every added radio beacon or installation of any kind, need to be kept constantly in mind.

Marker Beacons

A directive beacon of the type described is sufficiently well developed to insure that it will be used on the civil airways of the United States. It serves effectively to guide the aviator along his course. It is subject to the limitation, however, that it gives no indication as to the distance covered or as to the particular part of the route which is passed at any given time. This lack can be remedied

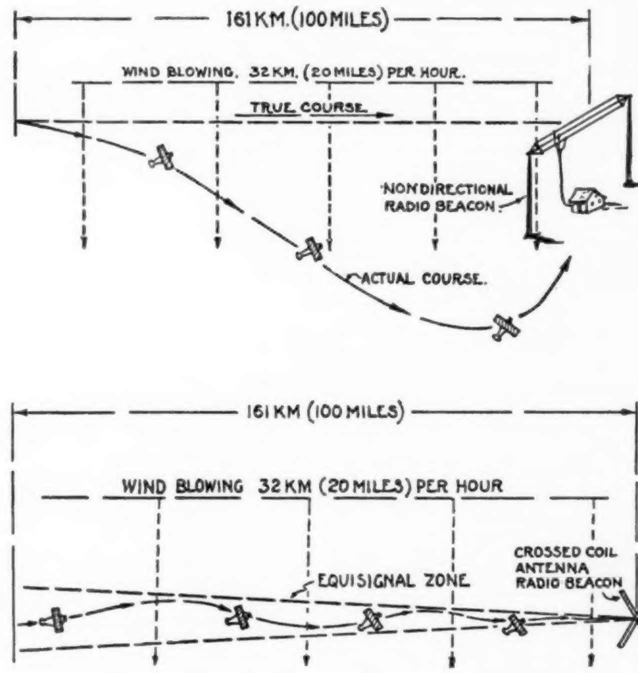


FIG. 6 COMPARISON OF EFFECT OF WIND DRIFT IN NAVIGATION BY DIRECTION FINDER (UPPER DIAGRAM) AND BY DIRECTIVE BEACON (LOWER DIAGRAM)

by the establishment of very low-power radio transmitting stations at intermediate points to serve as localizers or markers of those points. These low-power non-directional beacons will give a characteristic signal which will be heard and recognized by the aviator during a short interval when he is near and over these beacons. They will not mark a line of direction but simply mark a distance somewhat as mile posts on an ordinary road. Very simple radio transmitting outfits are being designed for this service, and it is believed that they will supplement the directive radio beacon in a most effective way.

Field Localizers

While the radio beacon will adequately direct flight along the course, it does not in its present form provide a positive means of determining the exact location of the landing field or of landing in fog. It serves in a general way as a field localizer since the width of the equisignal zone grows considerably narrower as the field is approached. It is quite possible, however, that it can be developed or supplemented so that the character of the signals or of the equisignal zone shall be particularized over the landing field and the exact location of the field definitely marked out. It is quite possible that further work on antenna systems for the beacon will accomplish this desirable purpose. A satisfactory field localizer would assist the aviator to a position directly above the field and direct him to a safe landing.

A method now used, and one which is capable of further development, is the simple one of having an observer on the landing field listen for the noise of the airplane and estimate its height above ground by the noise, sending this information by radio to the pilot. This involves utilizing the services of the ground personnel so that they can serve as the eyes or ears of the pilot for landing purposes. This same procedure may perhaps be used to aid in keeping the aircraft on a route, through listening at intermediate stations and indicating to the flier that he is passing a definite point or field on the route.

Several types of electrical field localizers have been developed in an experimental way. One of these which was worked out by the Bureau of Standards a number of years ago at the request of the Air Mail Service involved the use of a coil of wire extending around the confines of the landing field carrying 500-cycle alternating current. Using an amplifier, an aviator could hear this signal when over the field up to a height of several thousand feet. An arrangement of smaller coils carrying radio-frequency currents was also developed which accomplished about the same result.

None of the possibilities in the way of field localizers have been put in practical use. Perhaps the chief drawback to all of the plans so far developed is that special attention or activity is required on the part of the aviator. The object in view is so important that further work should be done on this problem, but the method which will eventually be adopted must be one which requires very little complication of apparatus and a minimum of special activity on the part of the aviator.

Direction Finders

Lighter-than-air craft and the larger airplanes will doubtless carry direction finders. The extra weight and complication preclude their use generally on the smaller airplanes. Aircraft which do carry them use either the simple rotating-coil type as used on ships or a special double-coil type which has certain advantages in operation through interference from the ignition system.

This interference necessarily makes direction finding on airplanes less practical than on the ground. On account of this there has been some development of the reverse system in which direction-finding stations are provided at certain points on the ground for determining the position of aircraft which have transmitting sets but do not carry a direction finder. England has two such stations for locating position of aircraft, one in the north and one in the south of that country. As aircraft move so fast it is desirable to have the aviator make frequent reports to the ground direction finders so that they can keep a plot of the craft's course and know the approximate position at all times. Trouble on aircraft can occur so quickly that in some cases the flier would only be able to report that he was landing; there would be no time for a bearing, and it would be necessary to send aid or search in accordance with the plotted course. In some cases the reports would merely cease, and failure to arrive in due time would make the plot a valuable reference point.

The use of direction finders is an alternative to the directive-beacon system previously described. Aircraft which travel only fixed courses marked out by radio beacons would have no use for direction finders. Those which fly over courses not provided with the beacons, however, will find radio direction finding a valuable aid.

Landing Altimeters

Work with aids to airplane navigation has first, last, and all the time the problem of landing as its chief difficulty. Much thought and experiment have been spent on methods to facilitate landing in fog, but the author finds that aviators declare that no mechanical instruments could ever give them sufficient confidence to make an actual landing when the ground was invisible. The radio beacon can guide a pilot to the landing field, and its location and outline can be given him by a field localizer device, but there still remains the problem of indicating to him the exact distance above ground during the last few feet of descent and actual landing. Various methods have been proposed or tried to give an indication of the exact distance above ground during this critical period when the airplane is settling to earth. All the methods offer great difficulties. They include electrical-capacity variation, sound reflection, and radio-wave reflection. The first of these is known as the capacity altimeter. It was developed by the Bureau of Standards and the Air Service in 1922, and is as promising as anything now known. Two wire structures are provided on the airplane, supported as far apart as possible from the ends of the wings and as far below the airplane as feasible; and the instrument utilizes the variation of electrical capacity between these two structures as the ground is approached.

The variation of capacity produces variations in the tuning of a radio circuit, which is indicated by an instrument. This instrument can be calibrated in feet above ground, and is effective in the critical range between ground level and some 30 to 40 feet up. It is still a question, however, whether the additional complication of the aircraft receiving equipment and the delicacy of the type of measurement involved will permit this to be developed into a practical operating method.

Conclusion

The foregoing has dealt only with the direct use of radio in connection with aircraft operation. The subject of the necessary communication between airports and other points on the ground in connection with aircraft operation is conceived as an entirely separate subject. In principle such communication can be effected entirely by means of wire telegraphy and telephony, and radio would not necessarily be required at all. The uses of radio here sketched are uses to which nothing except radio is adapted.

In carrying out its newly assigned responsibilities to provide aids to air navigation on the civil airways, the Department of Commerce has concluded that radio aids are indispensable. As the first step in establishing these aids the Bureau of Standards is at present engaged in setting up a model installation. In connection with this, experimental research work is being undertaken on those features of the radio aids which are not yet available in sufficiently perfected form. It is clear that the airways must be provided with a system of radiotelephone transmitting stations and directive beacons at certain intervals. At smaller intervals between the directive beacons, probably every 25 miles, are to be located the marker beacons. It is not yet certain whether the beacons will operate by means of an audible or a visual signal on the airplane, and the determination of this is one of the principal objects of the investigation now in progress.

It would be impossible to prophesy the limit of possibilities of radio in connection with air navigation. In addition to radiotelephony, the directive beacon, and the marker beacon, there remain the further possibilities of field localizers, direction finders, and landing altimeters. Research is in progress on these additional aids. They all offer difficulties, but will doubtless be eventually worked out and adapted in various forms to aircraft use. In any event, there is every reason to believe that radio will have a steadily increasing part in expediting, and increasing the safety of, air navigation.

Early Days of Transatlantic Radio

In recounting the birth of wireless in an exclusive interview to the New York *Times* (December 11, 1926), Guglielmo Marconi told of the first signals ever transmitted by wireless across the ocean. The test was of the greatest importance as doubt existed whether or not wireless signals would be interfered with by the curvature of the earth.

An antenna system consisting of twenty masts was erected at the sending end at Poldhu, in Cornwall, but a gale brought it down. An emergency antenna was therefore erected on only ten masts. The receiving end was at Signal Hill, Newfoundland, where a single wire was raised in the air by means of a kite.

Notwithstanding the very crude equipment used signals were obtained by means of a telephone connected to a self-restoring coherer, a device used in the early days of wireless and consisting of a small sealed glass tube filled with iron filings.

> Following the success of my experiment [Senator Marconi told the reporter] I was notified on behalf of the Anglo-American Telegraph Company that as they held a charter giving them the exclusive right to construct and operate stations for telegraphic communication between Newfoundland and places outside the colony, the work upon which I was engaged was a violation of their rights. I was asked to give an immediate undertaking not to proceed with my work and to remove my apparatus or legal proceedings would be taken.
>
> I was absolutely astounded at this communication, which, however, at least gave satisfactory assurance that one of the great telegraph and cable companies not only believed in but also feared the possibility of wireless transatlantic communication. I will say nothing further on this matter now, and only mention it in order to show why my experiments were cut short on that occasion, and why I was forced to abandon a demonstration which I had intended to give on the following Monday on Signal Hill to the Governor of Newfoundland, Sir Cavendish Boyle, and a number of other gentlemen who were highly interested in the results of my experiments.
>
> When the reason for my discountinuing my experiments became known I was almost deluged with offers of sites for the erection of experimental and permanent stations. Among others, Mr. Fielding, Finance Minister of the Government of Canada, offered me on behalf of that Government every facility for the location of a station in Nova Scotia, which I decided to accept.

Chromium Plating

Hardness and Tarnish Resistance of Chromium—Bath Used in Chromium Plating—Deposition Difficulties—Costs Involved—Possible Applications

By WILLIAM BLUM,[1] WASHINGTON, D. C.

JUDGED by the interest displayed and the publicity attached to this subject, chromium plating might well be called the "sensation" of the last few years in the field of protective coatings, a field in which there have been but few other radical changes in the preceding decade. Among the questions many chemists and engineers are now asking are, "What is the future of chromium plating?" "Is it a practical process?" "What is its probable value when applied to engineering materials?" In short, can we use it?

In what follows, the author will attempt to answer or at least to discuss some of these questions, especially from the standpoint of the mechanical engineer. In doing so he is limited principally to the experience and contact of the Bureau of Standards, because so little authentic information has been published on the subject, especially in this country. However, as a large number of industrial research laboratories are now engaged in the study of chromium plating, and hundreds of firms are trying it out for various purposes, it will no doubt be possible within a few years to make much more definite statements than are now justified.

In order for any new process or product to compete permanently with the established procedure, it must have certain definite advantages. It may therefore be well, before discussing methods and applications of chromium plating, to consider those properties of the metal which make it of special interest.

Outstanding Properties of Chromium

The outstanding property of chromium, when deposited under appropriate conditions, is its extreme hardness as measured, for example, by its resistance to scratching. A bright chromium deposit when tested in the Bierbaum apparatus with a sapphire point and a given load yielded a scratch with a width of about 0.7 micron (the narrowest scratch of any metal thus far examined), while the cold-rolled steel on which it was deposited yielded a scratch about 2.2 microns in width. The great hardness of the chromium, and the fact that this as well as its other properties may be varied by the proper choice of plating conditions, at least justifies its consideration wherever hardness is an essential factor.

Another property of chromium that is distinctive is its resistance to tarnish or oxidation under many conditions of exposure. Thus it will stay bright for long periods not only in an ordinary atmosphere, but also when exposed to a high humidity, to salt air, to fairly elevated temperatures, to molten tin and zinc, to many laboratory fumes, and to concentrated nitric acid. It is readily attacked and dissolved, however, by hydrochloric acid, and more slowly by sulphuric. This resistance to tarnish therefore justifies its consideration wherever a bright surface is necessary, e.g., on mirrors, even though the reflecting power of chromium is somewhat less than that of silver.

Although chromium itself resists tarnish, it does not necessarily protect an underlying metal such as steel against corrosion if the latter is anywhere exposed. Thus it may be readily shown that chromium-plated steel quickly corrodes at any points where there are pores or pinholes in the deposit. In this respect chromium is similar to nickel and copper and unlike zinc and cadmium, which latter will protect small areas of exposed iron because the zinc and cadmium dissolve more readily than the iron. Any superior protective action of chromium plating on steel above that of nickel plating must depend upon producing more nearly impervious deposits of chromium than of nickel. From present indications it appears probable that for such uses chromium will generally be applied over nickel plating of good quality, in which case the chromium is chiefly useful for its hardness and tarnish resistance.

The Bath Used in Chromium Plating

With the definite advantages it possesses, it is a matter of surprise to many that chromium plating has been such a recent development. However, this condition is not the result of any lack of interest in the subject, but of inability until recently to so define and control conditions that consistent results may be obtained under industrial conditions. Chromium was electrodeposited by Bunsen as early as 1854, and since then numerous papers and patents have been issued on this subject. Of the more recent papers, that published by Sargent[2] in 1920 is probably of greatest interest, as most of the methods that have been proposed since that date represent modifications of Sargent's solution, or of his operating conditions.

Sargent recommended a bath of which the major constituent is chromic acid (CrO_3) in a concentration of about 250 grams per liter (33 oz. per gal.). To this he added a small amount, e.g., 3 to 5 grams per liter (0.4 to 0.7 oz. per gal.) of chromium sulphate, $Cr_2(SO_4)_3$. From such a bath Sargent and others have obtained good chromium deposits, but frequently the results have been erratic. H. E. Haring, from a study at the Bureau of Standards,[3] concluded that in such a bath it was necessary to regulate the acidity. This is accomplished practically by having present in the bath a colloidal suspension of chromium chromate, which may form automatically or may be produced by the addition of any basic or reducing substance.

Even more important than the exact composition of such a bath is the control of operating conditions, especially the temperature and current density. These have an appreciable effect in all plating operations, but in chromium plating relatively small variations in these factors may change entirely the character of the deposit, or even prevent deposition entirely. Three principal types of chromium deposit may be produced, though of course these shade gradually into each other. (1) At too low a current density or too high a temperature, a "milky" deposit is produced. This is relatively thin owing to the very low cathode efficiency under such conditions. (2) At the appropriate temperature and current density, e.g., at 45 deg. cent. (113 deg. fahr.) and 10 to 20 amp. per sq. dm. (100 to 200 amp. per sq. ft.), a bright deposit is produced. (3) At too high a current density, or too low a temperature, the deposit becomes "frosty," gray, and "burnt." Of these deposits the milky form is the softest and the bright is the hardest, as measured by the scratch test.

Difficulty in Depositing Chromium Uniformly on Irregularly Shaped Articles

With an appropriate solution, temperature, and current density it is a relatively simple matter to produce bright, hard deposits of chromium upon those articles where a nearly uniform current density may be secured, e.g., upon nearly plane surfaces, cylinders, etc. Upon irregularly shaped articles, and especially those having deep recesses, it is very difficult to get a continuous deposit of chromium of uniform properties. Thus it may then be found that no metal is deposited in the recess, or else the deposit on the projecting parts is gray and spongy. The latter type of coating is hard to buff to a bright surface. This poor "throwing" power of the chromium solution is due principally to the fact that the current efficiency decreases rapidly as the current density is lowered. Thus at 45 deg. cent. (113 deg. fahr.) the cathode efficiency at 20 amp. per sq. dm. (200 amp. per sq. ft.) is about 18 per cent, while at 5 amp. per sq. dm. (50 amp. per sq. ft.) it is only about 7 per cent, and at slightly lower current densities it is practically zero. This limitation appears to be an inherent defect of baths containing

[1] Chemist, U. S. Bureau of Standards.

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[2] Transactions of the American Electrochemical Society, vol. 37 (1920), p. 49.

[3] *Chemical and Metallurgical Engineering*, vol. 32 (1925), p. 692.

chromic acid, and while minor improvements in the throwing power may be effected, there is little reason to believe that it can ever be made to approach that of a nickel-plating bath, much less that of a cyanide copper solution.

Costs Involved in Chromium Plating

Another factor which may affect the introduction of chromium plating on a very large scale is the relatively large power cost involved. Ordinarily in electroplating the cost of power is negligible, e.g., of the order of one cent or less per square foot. With chromium, however, the power cost may be from five to ten times as great. This is due to several factors, especially (1) the low electrochemical equivalent of chromium in chromic acid in which it has a valence of six; (2) the low cathode efficiency of chromium deposition, generally about 15 per cent; and (3) the higher voltage, generally 8 to 10 volts, required by the use of insoluble lead anodes and high current densities.

The cost of the chromium itself is not prohibitive, as the metallic chromium in chromic acid at 40 cents per lb. costs about 80 cents per lb. as compared with nickel at 45 cents. A coating as thick as 0.025 mm. (0.001 in.) represents only about three cents worth of chromium per square foot. The total cost of chromium plating is certain to be somewhat greater than that of nickel, as the investment, the power, and the labor costs are all higher in chromium plating. On those products for which the chromium has unique advantages, and especially where the general labor cost represents a large part of the entire expense, the greater cost of the chromium plating may be fully justified.

Possible Applications of Chromium Plating

Printing Plates. Among the possible applications of chromium plating, those dependent upon its great hardness are especially promising. One interesting example is its use on plates for printing currency and securities at the U. S. Bureau of Engraving and Printing, where the process and conditions developed by H. E. Haring at the Bureau of Standards are in successful operation. Some years ago the Bureau of Standards coöperated in the design and installation of a plant for reproducing these plates electrolytically. The plates produced by this process have a nickel surface, followed by alternate layers of copper and nickel, finally sweated to a steel plate. These plates are "intaglio," i.e., the designs are below the plane surface, and before each impression the plate is inked and rubbed first with burlap and then with the hand. As all inks contain some abrasive particles, there is considerable wear on the plates. As was expected, the plates with a nickel surface did not last so long as the case-hardened steel plates that were formerly used exclusively.

By the application of about 0.005 mm. (0.0002 in.) of chromium to the electrolytic nickel plates it was found that their useful life can be increased to about four times that of the nickel or twice that of the hardened steel plates. The impressions are usually sharper, and through the use of a smaller number of plates greater uniformity and security of the product are obtained.

In other branches of the printing industry it has been found that when very long editions are required, e.g., of labels and soap wrappers, chromium-plated electrotypes may be used to produce from three to six times as many impressions as can be made from the nickel electrotypes.

Gages. Of more direct interest to engineers is the application of chromium to gages. In a recent study at the Bureau of Standards[4] the performance of chromium-plated plug gages was compared with that of hardened steel gages. In these comparisons a wear-testing machine devised by Messrs. French and Herschman was emloyed. By its use two gages were automatically moved up and down in hardened steel rings, and the wear was measured after a determined number of such gagings. From this study the following tentative conclusions were reached: When exposed to sliding friction, with no abrasive present, the chromium-plated gages resisted wear about five times as well as any of the steels tested. When, however, abrasives such as fine emery were present, the chromium-plated surface, while still superior to the steel, was only 30 to 50 per cent better. This latter result does not, however, mean that the chromium plating is unsuitable for resisting wear caused by finely divided abrasives such as emery under all conditions. Thus it was found in lapping wear tests that the chromium resists wear from two to four times as well as the customary gage steels. It is at least probable that by depositing the chromium under different conditions, coatings may be produced which are best suited to resist each particular type of wear. For all those conditions of service in which chromium-plated gages may be found applicable, they have the advantage that a relatively soft steel may be used as a base and thus dimensional changes with time be avoided.

In the experiments thus far conducted at the Bureau a relatively thick chromium deposit (about 0.02 mm. or 0.0008 in.) was applied, after which the surface was ground and lapped to the desired dimensions, leaving a somewhat thinner coating of chromium on the gage when it was tested. A simpler and more economical procedure would be to apply a relatively thin chromium layer (e.g., 0.005 mm. or 0.0002 in.), to a finished, accurately under-dimensioned gage. The latter could then be used directly after plating, and, after a predetermined length of service during which about half the chromium would have been removed, the remaining chromium could be readily dissolved off and a new coating applied. Whether such a procedure will prove practicable remains to be seen. While both laboratory tests and plant practice have indicated that chromium plating may not be universally advantageous on gages, the results are certainly sufficiently promising to warrant further investigation and trial.

Surfaces Exposed to Wear. The experience with gages at once suggests the application of chromium to other steel surfaces exposed to wear and which now require special hardening processes. A few observations indicate that chromium plating on certain cams is practical and advantageous. On gears it may be difficult to produce satisfactory deposits in the depressions, and the wear on the teeth is much more likely to detach the chromium coating. On stamping dies or other surfaces exposed to severe impact it is at least probable that a light chromium coating would furnish little protection against the deformation of a soft-steel base. If, however, chromium could be made to adhere permamently to a case-hardened die it would preserve the details. On dies used in molding plastic materials the application of chromium will probably be advantageous. More extensive experience than is now available, or at least published, will be required before a final conclusion can be reached regarding these and similar possible applications.

Corrosion-Resistant Coatings. Uses of chromium dependent upon its resistance to some specific corrosive condition include such applications as the following: Molds for vulcanizing rubber may be chromium plated to prevent sticking of the rubber to the mold. The resistance of the chromium to sulphur or many sulphur compounds which leads to the above use has also caused it to be considered for oil-cracking equipment. The resistance of chromium to oxidation has suggested its use on glass molds and on rollers for making plate glass. So far as is known, the latter two uses are still in the experimental stage.

Reflectors. The luster and permanence of chromium plating warrant its consideration for reflectors, especially those that are exposed to sulphur fumes such as in locomotive headlights and flood lights. Even though its reflective power is only about 60 per cent as compared with 90 per cent for silver, the rapid tarnishing of the silver more than compensates for this initial difference.

Whenever a bright surface is required that is not exposed to severe corroding conditions the application of chromium directly to steel will be advantageous, e.g., on rules and scales for shop use. However, where steel articles are to be exposed to the weather it will be found desirable to apply a coating of chromium (e.g., 0.005 mm. or 0.0002 in.) over a substantial nickel coating (of 0.025 mm. or 0.001 in.), or, still better, over a coating composed of a copper and a nickel layer, or of a nickel, copper, and nickel layer. In the automobile industry great interest is being shown in such applications of chromium plating, and on one make of car the radiator is now chromium plated. As previously indicated, the value of chromium under such conditions depends largely on its luster and the resistance it offers to tarnish and abrasion. There is little reason to believe that the chromium will materially increase the re-

[4] H. J. French and H. K. Herschman. Preprint 18 of the American Society for Steel Treating, September, 1926.

sistance to corrosion of the steel under severe conditions of exposure.

On brass articles such as plumbing fixtures, where there is little tendency for the base metal to corrode, the chromium may be plated either directly on the brass or on a nickel-plated surface. In the latter case, however, it is essential for the nickel plating to be very adherent, otherwise it will peel during the chromium plating. The more rapid adoption—or at least trial—of chromium plating for such fixtures is undoubtedly hampered by the poor throwing power and the greater personal attention required for consistent production.

With so many research laboratories engaged in the study and development of chromium plating, it seems safe to predict that even though no revolutionary developments appear probable, at least with the present type of bath, a fund of experience will soon be gained, upon which will be based the application of chromium plating to those many purposes for which it is especially suited. Chromium plating is not a panacea—it will not replace all other forms of plating. But it will serve, and indeed has already served, many purposes better than other metals, and some that other metals cannot serve.

Preferred Numbers[1]

Standardization Based on Calculation—Application of Preferred Numbers Means Simplication—Examples—Difficulties Encountered in Introducing Preferred Numbers Through Adhering to Old Methods—Preferred Numbers Generally Applicable

BY A. HERB,[2] GÖPPINGEN, GERMANY

IN ORDER that standardization in a plant shall be a complete success, it must first of all permeate the whole works and especially the machines subject to standardization. Every one who is active in this field of standardization knows how difficult it is to obtain uniformity when it has to be applied to different types of machines produced in one plant. To reach a satisfactory result it is necessary to lay down comprehensive fundamentals on which the whole work of standardization as applied to machine design shall rest. These underlying principles give a ready means of calculating the values which are essential to the establishment of the measurements. However, before any attempt to standardize is made, a fixed program of procedure must be laid down which will embrace all possible requirements considered from the manufacturing standpoint, in order that a satisfactory standardization may be derived therefrom.

To such a standardization were we forced to turn in our factories, and in order to accomplish this it was first necessary to provide the above-mentioned basis.

Forming a Basis for Standardization

After extremely careful and accurate calculations it was found necessary to ascertain, on the basis of many years of experience, the best efficiency of a certain type of machine. This was possible only when a great many performance curves from actual tests had been obtained. To accomplish this task we made use of graphical methods and alignment charts, and to our amazement encountered as a result the repetition of a whole series of numbers. These numbers were actually the preferred numbers of the N.D.I. which, as we know, increase in a geometrical progression. The practical conclusion was that we should employ those numbers in our calculations, and the results were again "preferred numbers." With the assistance of these preferred numbers we then graphically established a standardization scheme, and abandoned, not to our disadvantage, the formerly employed arithmetical progression.

The work of calculation and deliberation has been greatly reduced; for after a single calculation of a certain size the values for the other sizes can be immediately written down since they are within the same law, due consideration being given to the number of intervals within the decimals. We quickly disposed of the idea that geometrical progression is not suitable for standardization purposes, for the reason that in this progression the lower values are too close together while the higher ones are too far apart, since the preferred numbers given in the DIN sheet No. 323 are of the 40-number series and as such offer a wide range; in fact, even some of the lower numbers could easily be omitted. However, in case it should be found that the numbers given in DIN sheet No. 323 are inadequate to care for the various details, this can be easily and, as the author believes, correctly remedied by adding an 80-number series to the sheets in question. In this way it is possible to extend to a wider field the values and advantages of geometrical progression, in standardization work.

[1] Translated from the German by A. L. Fink, Morgan Construction Co. Worcester, Mass.

[2] L. Schuler & Co.

Application of Preferred-Number System to Press Design

On the basis of the foregoing considerations the preferred numbers were made full use of, and the following examples of their applications are submitted. In the standardization of our eccentric presses the task was to ascertain the cutting pressure, the punch diameter, the area of the surface to be severed, the thickness and strength of the plate, the power, and the distance from the center line of the punch to the back of the gap. Since the last is a function of the outside diameter of the press table, and this again is a function of the punch diameter, the dimensions form a geometrical series. We therefore put these values in such a series, taken from DIN 323, in accordance with our experience since its publication. We then figured the cutting pressures and corresponding power requirements, and the values obtained were again numbers in a geometrical series. As the cutting pressure and power are the deciding factors in the dimensioning of the individual machine parts, we also placed the dimensions of these parts in a geometrical series.

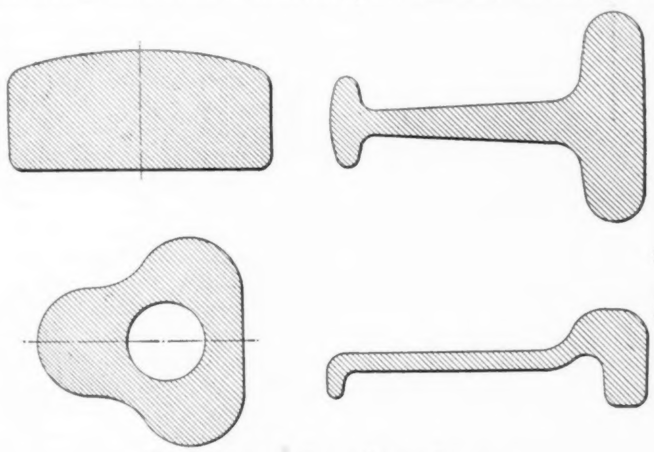

FIG. 1 VARIOUS PRESS-FRAME SECTIONS

It so happened that in the determination of the section of the frames—which for the different types are of different shape, as seen in Fig. 1—the moments of inertia and section moduli also formed a geometrical series. The advantage of this was that it was only necessary to determine the dimensions for one section, and after ascertaining the steps corresponding to the increase of pressures, power, and overhang, the dimensions for other sections could at once be written down and used by the designer. In the same way we determined the dimensions of journals and shafts. In the standardization of flywheels for our machines, the main object was to cover the range of power requirements with as few

numbers as possible. After the various values of D_s (radius of gyration) in Fig. 2, corresponding to the machine sizes, had been placed in the proper geometrical series, it was easy and required but little figuring to find all the other dimensions of the rim. Even the weights of the various rims now theoretically run in a geometrical progression.

Standardizing Various Machine Parts

The standardization of our pulleys was also easily carried out. Since the capacities of our machines ran in a geometrical progression in accordance with the preferred numbers, it was obvious that for our calculations it was necessary to place the speeds and diameters again in a geometrical progression. From this the derived peripheral velocities followed the same progression. We then selected the width of the pulleys again in accordance with the preferred numbers, and the calculated shaft diameters and also the bores gave again a series of values in accordance with the preferred numbers. Following our former designs we were now in position to determine in a simple manner the distance between the bearings in accordance with the preferred numbers. Having calculated the deflection and the angle of torsional deflection of the shaft for a single pulley, it was necessary only to determine the intervals corresponding to the values of the pulley diameters, widths, and bearing distances thus derived, and all values for the other pulleys could immediately be written down. Since the speeds followed the preferred-numbers law, the transmitted-horsepower values were also easily obtained. Having selected the permissible belt loads, taking the speeds and diameters into consideration and placing them in a series of preferred numbers with one calculation only, all other values for the transmitted horsepower were determined.

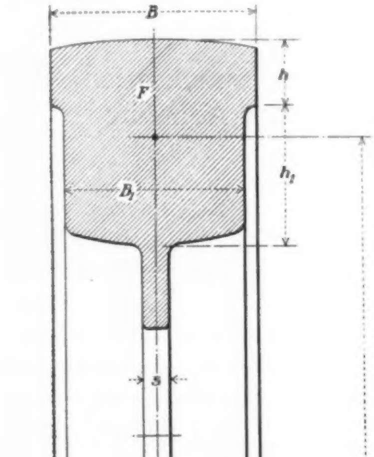

Fig. 2 Part Section of Flywheel

Of course check calculations were necessary for the intervals, varying with the loads, widths, diameters, and speeds, but nevertheless the actual work of calculation was small. Since the bores followed a certain fixed law, the values for the hub diameter were also predetermined, and it was only necessary to place the curve two intervals higher. The dimensions of the arms were also selected in accordance with the preferred numbers. For the standardization of this particular machine element the preferred numbers were of special merit. Using them in the same manner as in the above examples it was found that they could be applied to all other machine elements. The heights, widths, and dimensions for the whole shape (as radii, etc.) having been selected by preferred numbers, we established standard machines throughout, that is, machines which were standard not only in single parts but in all parts.

Considering production, this was of the utmost importance, inasmuch as the preferred numbers could be applied without delay in the standardization of our other machine types. The preferred-numbers system by its very merit thus became our manufacturing-dimensions standard. In the interest of interchangeability and impelled with the desire to employ DIN standards throughout, we also decided to adopt the DIN fits. This placed us in a position to select our gages also on a preferred-number basis, and, what was especially to our advantage, most of the important dimensions (bore, shaft, and journal diameters) followed the same rule. We were therefore able to keep our outlay for gages within economical limits, and their upkeep was greatly reduced. Our boring tools and reamers were also simplified, and therefore purchased somewhat cheaper. Also the management and upkeep was immediately made easier, particularly so in connection with the tools. A greater range may be given them, and in their design and construction the same advantages as above mentioned may be obtained.

Using the preferred numbers in the construction of our machines and their parts, including gages, fixtures, and machine tools, we therefore accomplished just what we had set out to do, namely, to establish standards following a certain law. In the application of these standards our previous extensive experience was also fully utilized.

General Advantages of the Preferred-Number System

It is unfortunate that after the introduction of the DIN standards difficulties arose from time to time, because in selecting the standards very little attention was paid to the preferred numbers. Arbitrary series of numbers are often selected, but we should bear in mind all the advantages to be derived from the adoption of the preferred numbers and also that after having been extensively used, they will become as general as are the arbitrary-number series today. Taking into consideration the results accomplished, it is hardly necessary to prove that a basis can always be found which renders it possible to select the starting point of a given calculation in such a way that the derived results will always remain "standard." One advantage of the preferred-number system lies in the fact that all strength calculations follow exponential laws, and since these powers are in a certain sense geometrical progressions, it should not be difficult to adopt them. Therefore there is nothing to prevent the adoption of the preferred numbers, it being only necessary to settle on what the steps or intervals should be, and this can be decided upon from the standardization plan. For example, if the terms in the 10-number series are insufficient, then the 20- or 40-number series may be used. This may often be necessary because of the particular shape being dealt with, but the great advantage is that with the shape of but one machine or machine part definitely ascertained and with the intervals or steps correctly determined, all other dimensions can be easily selected.

In view of these advantages the use of preferred numbers is to be recommended, especially for new constructions, since after ascertaining a single dimension all others which are required for construction follow, and they may be readily determined by subordinate workers.

In the commercial production of combustible gases certain impurities always formed are carried from the combustion chamber with the gas as finely divided dust, or particles, present as a vapor when the gas is hot and condensing when it is cool. These impurities include dust, ash, cinders, and various tars, oils, and ammonia. If not removed before the gas is burned they will choke up the burners and valves and settle out in flues and pipes, necessitating frequent cleaning. There is a further advantage in removing the impurities, as some of them will yield valuable by-products.

It is good practice to remove the dust, ash and cinder particles while the gas is hot and the tar and oil contents are in vapor form. The latter impurities are then removed separately, after the gas has cooled.

Equipment described in this article is being used to remove dust, ash and cinder particles from the hot gas in the first stage of cleaning. The apparatus used to remove tar and oil in the second stage of cleaning is similar.

Automatic equipment has now been designed such that it is only necessary to close the knife switch, and the automatic controller takes care of all the rest. The various units are stopped, cleaned out, started up again, one after the other at the desired interval, without attention from an operator. The controller never neglects to shut down the equipment at the proper time, which makes for the best operating condition. Neither does it ever get mixed up in the sequence of its operations, which fact increases the safety of the process.—*The Iron Age*, Nov. 11, 1926, p. 1345.

The Change of Viewpoint of the Machine Shop

The Turning Away of Machine-Shop Practice from Purely Individual Skill and Experience to Well-Founded Theory, and Its Gradual Change from an Art to a Science

By A. L. DeLEEUW,[1] NEW YORK, N. Y.

LIKE everything else in this world, shop practice has undergone and is undergoing changes. Some of these we have noticed because we could not help noticing them. They were or are of such outstanding importance that they impress themselves on us. They have become landmarks, milestones when we look back along the road we have traveled. Meanwhile there are other changes which have come to pass in a slow and unobtrusive way, which have gone on building up accumulatively and have become of as much importance as some of the epochal changes, but which have been left unnoticed because of their slow growth.

If it were worth while philosophizing about them we would probably come to the conclusion that in some cases the great inventions and changes were the result of the lesser ones, while in other cases the exact reverse would be true. To use a mechanical illustration, we may say that a pressure has been built up gradually, until finally the bursting point has been reached. We notice the explosion but we did not notice the gradual building up of that pressure. Such coming to a head of slow and gradual changes is particularly apt to occur when these slow changes are of a non-material nature—when they are changes of the viewpoint of men.

It is well from time to time to take stock of conditions as we find them so that we shall know what material we have with which to build.

Machine-Shop Practice Formerly Considered Entirely a Matter of Skill

It is not so many years ago when no one could have a position in a machine shop unless he was a practical man. Of course there were clerks, etc., but after all they were not in the shop itself. From manager down to youngest lathe hand, every one was supposed to be a practical man—that is, a man whose knowledge was entirely based on his own experience. If once in a while a man penetrated into a shop who had not come up from the ranks—in other words, whose knowledge did not come into his brain by way of his finger tips and the muscles of his arm—he was looked on with suspicion, often with derision, and he had a hard road to travel before he could impress himself on his co-workers.

Machine-shop practice was considered entirely a matter of skill. In other words, machine-shop practice was entirely an art—at least in the minds of the workers. Foremen, superintendents, managers, designers, all were supposed to come from the shop. The few designers who had arrived by a different road were looked on with suspicion, their work received severe criticism, and every fault, every mistake, every point about which there might be a difference of opinion, was hammered at and pointed out as the result of the foolishness of having things designed by a man who was not practical.

Though a practical man was supposed to be a man who had obtained his knowledge of the art by his own experience, the fact was overlooked that if such were actually the case, no worker could know more than a small fraction of what he did know. The apprentice coming into the shop was taken under the wing of some mechanic, or more likely some mechanics, and began to absorb the knowledge of these men; and even if he was left alone and did not receive instructions from any one, yet he saw his surroundings, he saw what was being done, what other people had learned, and so the major portion of what he came to know was really the absorption of existing knowledge, but not through his finger tips or through the muscles of his arm.

In fact, the entire arrangement of the shop, the machines in it, the labor-saving devices, the material-handling devices, the form of the tools, the methods of operation, all had been gradually developed through years, sometimes through centuries, and represented the accumulated knowledge of the art. The records of what had been accomplished in the past were in the form of instruction handed down by word of mouth, and in the material products of past efforts. They were in the form of a book, the pages of which were strewn hither and thither, and written in a manner which was hard to read. It was difficult for any one to gather up these pages and read them as a complete book. But difficult as the reading might be, the record was there. It was not lost, it was merely badly kept.

The Practical Man and Progress

The man who had acquired skill or knowledge, or both, partly by his own experience, partly by reading the scattered pages of past attainments, was called a practical man, and the world was looking toward the practical man for future progress.

It is a good thing for the progress of the world that strictly practical men are extremely scarce, if there is even one. The strictly practical man can only do what he knows, and nothing else. The moment he lets his mind roam into new regions, the moment he thinks out an improvement, the moment he tries to group or classify his own knowledge or tries to find reasons why things are as they are, that moment he ceases to be a practical man. He becomes a thinker, a theorist. Some men are largely practical and to a very small extent theorists; others are largely thinkers, and to a very small extent practical men—in fact, they are often impractical; and there are all shades and degrees in between. All improvements, all progress, have come from men who were not wholly practical. The finest combination lay in those who had skill and thinking capacity, experience and thought; and the reason why this combination was necessary to the past was that there were no clean-cut records, so that no one was in a position to make the experience of others his own. If he knew what some one else had done, there still remained the doubt as to whether it was correct or faulty, because the reasons why were not given and were sometimes hard to find.

The outstanding feature of the attitude of the shop man in the past may be said to be this: that he failed to ask "why" and "why not." This attitude has changed to such a remarkable extent that it is timely to take stock of our present conditions, to see where we are and where we are going.

Attitude of Shop Men in the Past

Going back less than thirty years we find the following illustrative facts which have impressed themselves on the memory of the author. In one of the largest and best-known machine shops of that time the general foreman did not know the speed of the lineshaft or of any of the countershafts, nor did he know any of the speeds at which any of the machines were capable of running. Neither did the foreman or any of the machine operators. The skilled mechanics knew, or thought they knew, on what step of the cone pulley the belt should be for a certain job and whether the back gear should be in or out, but what the cutting speed for the work was they did not know. As a rule, the same ignorance prevailed about the feeds, though in this case a few of the men could actually tell what feeds they were using for certain jobs. Every new job which came in was a source of experimentation as to feeds, speeds, depth of cut, shape of tool, etc. If the operator had had some experience with some job which had some general resemblance to the one in hand, he would be guided by that experience, if he remembered the data; but often his memory was at fault and he would come to the conclusion that, although the job seemed to be about the same, it was after all quite different; but there was no question as to "why" or "why not."

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To tell any of these men that the thickness of the lathe chip was not the amount of the feed was like telling him fairy stories. It sounded interesting, but of course it wasn't so—and by the way, how many mechanics are there at the present time who still do not know that thickness of chip and amount of feed are not the same? And how many are there who still do not know that the length of the planer chip is not the same as the length of the stroke?

One of the common questions which machine-shop mechanics would discuss among themselves with great gusto was whether in a multiple boring head the tools should be progressively advanced in an axial or in a radial direction, and there was invariably a shaking of heads and an unbelieving stare if one dared to tell them that it should be neither the one nor the other.

It is only a few years ago that the teeth of inserted-tooth milling cutters were set at an angle with the axis, but not at an angle with the radius, in the belief that this setting constituted rake.

What does all this show? In the opinion of the author it shows that there was no tendency on the part of the shop workers to ask the "why" and the "why not," but to depend on experience only; in other words, to make of machine-shop work an art and not a science.

The New Spirit in the Machine Shop

One of the great changes which has taken place in machine-shop practice and which has come about slowly but progressively is that now the best men in the machine shop are asking for reasons and are making records.

We are still very far from taking the scientific view of this work, but we are headed in the right direction. The author believes that this change of view is of as much importance as the greatest mechanical innovation or invention that has modified our machine-shop practice, and that it is desirable at this time to see how far this new spirit has advanced and how far it has yet to go.

The two elements which we can point out as prominent in the development of this new spirit are the introduction of high-speed steel and of the motor drive. The first one confronted the mechanic with an entirely new set of conditions, and made him feel that after all he did not know the things he thought he knew. The second made it absolutely necessary for him to take cognizance of the speeds of his work, the number of revolutions of the machines, and all kinds of positive facts and data which heretofore had been neglected, or at the best were only in his subconscious mind. New instruments were invented to make it possible for the man to know with certainty the speed of a cut. A new profession came into existence: that of the "feed-and-speed boss." Though the feed-and-speed boss was often quite an unmitigated nuisance, the fact that he existed shows that there was a feeling that not everything could be left to the individual experience of the mechanic. The fact that often the feed-and-speed boss did not know as much as the mechanic he tried to instruct did much to counteract this feeling; but after all, once mankind wakes up to the acknowledgment of its own ignorance there is likely to be progress, and that regardless of whether the first method pursued is the best one or not, and regardless of how many setbacks there may be.

The mere fact that chips were blue instead of white—which, by the way, is no particular merit of the chip—caused mechanics to study chips, or at least to look at them, to notice their peculiarities, and caused them to think about the way they were made. Though even at the present time we are not sure as to just how a chip is generated, yet the fact that we are thinking about it has led to a great deal of progress in machine operation. It has also led to a great deal of progress in regard to the shape of tools.

Old Conservatism of Men Depending on Experience a Retarding Factor

Here, however, the old conservatism of the man who depends upon his experience only has been a retarding factor. It is even now difficult to convince the average shopman that it is a good thing to have tools ground in the tool room in a uniform manner and according to some system. Even now most men believe that they are the best judges as to how a tool should be ground for some job or other. The fact that no two people grind a tool the same way for the same job does not seem to affect their conviction that each man knows best how to grind his own tool. This belief is probably based on the use of hand tools. The way a carpenter or patternmaker handles his chisel makes it advisable for him to grind that tool himself, because if it were ground by some one else it might not have the cutting angle corresponding to the position of his arm. The same would be true for tools used on a hand lathe. How this argument can affect a tool which is held rigidly in a machine is perhaps hard to see, yet it is not at all unlikely that the sharpening of the hand tool is still controlling the sharpening of our lathe and planer tools, etc.

There is still considerable discussion among mechanics as to when the lathe tool should be set above, on, or below the center, and the lathe maker still makes his tool rest so that the mechanic can set his tool any one of the three ways. So long as each mechanic grinds his tool by hand and by eye, the tool rest must be made that way. But when lathe hands have finally come to the conclusion that some one else may know as well as they how to grind a tool, that feature of adjustability on the tool posts can be dropped, for then every tool will be made correct and can be set in one definite way in the lathe. Now each tool is made more or less wrong and has to be set above or below the center so as to make the final results right.

Interchange of Experiences Brought About by Introduction of High-Speed Steel

When the machine shop was confronted with an entirely new set of conditions due to the introduction of high-speed steel, men began to interchange experiences. They found that one man could not run more than 70 ft. per min., whereas another could run at 80 or 90 on the same material. Gradually the fact was brought out that there is a relation between feed, speed, and depth of cut. Perhaps the greatest merit of Taylor's On the Art of Cutting Metals lies in the bringing out of this relation. Shopmen began to realize that there was some kind of law which governed the most economical operation of tools in a machine, and that this law was not a simple one; and they were willing to acknowledge from time to time that their experience was no longer sufficient. They began to ask advice. In short, they were in a frame of mind to learn not alone by experience but by the knowledge of others. When such knowledge differed from their own experiences they would naturally discuss the matter and ask the reason why, and if such reason could be given and they were convinced of its correctness, it became the foundation for a line of reasoning of their own.

This interchange of experiences, this thinking out what should be done under a given set of conditions, is so common with the best men in machine shops today that it may seem strange that attention is called to it in this paper. But it has been going on for but such a short period and has crept in so gradually and yet is of such major importance, that it is well worth while to bring out prominently the fact of its existence.

Day of the Theoretical Man at Hand

We have not yet arrived but we are arriving at a condition of affairs in which practical experience will be considered as the foundation but not as the end of knowledge, and in which the "why" and the "wherefore" will call more and more for close observation and clean-cut thinking. In other words, the time for the theoretical man has arrived. Not the man who merely has an idea that such and such is the case, but the man who carefully collects facts, groups them, classifies them, finds their interrelation, makes an intelligent guess at the cause of them all, tests out this guess by new experiments, and if he finds nothing which contradicts his hypothesis, says that he now has found a theory covering the facts he knows. If he is of a true scientific mind he will keep that mind open; he will not say that he has found the final theory, but merely that the theory appears to be correct so far as known facts go. New facts, new experiences may alter the theory, and he is ready to make the change as soon as new testimony is presented.

Again, in other words, the best men in the shop are ready to consider machine-shop practice as a science based on art, and not merely as an art.

The development of a science requires two things: thinkers

and experiments. Thinkers there have been right along, but experiments have been few and far apart. It is gratifying to see that some of the universities now devote a certain amount of attention to the fundamental data relating to machine-shop practice. It is also gratifying to see that The American Society of Mechanical Engineers has finally taken up this matter and has now a committee at work on the gathering of data and the fostering of experiments along the lines mentioned. It is perhaps not so gratifying that there is a great clamor in certain corners for that kind of experiments which shall lead immediately to improvements in practice. It is well understood among scientific men that scientific research must have no other aim than the finding of truth, regardless of whether this truth can be immediately turned into profits or not. That it does so ultimately is well established by years of experience and hundreds of cases. The greatest profits will be made by forgetting them entirely while the research is going on, and the best results of research will be had by going as near as possible to the root of the matter so that the practical man shall be able to solve the individual problems he meets by his knowledge of fundamentals.

Once more be it said that one of the outstanding improvements of later years has been the turning away from purely individual practice to well-founded theory; the gradual change from machine-shop practice as an art to machine-shop practice as a science.

Interconnections and High-Pressure Industrial Power-Plant Design

Discussion of Interesting Papers on These Subjects Presented at the Power Session of the A.S.M.E. Old Dominion Meeting, Richmond, Va., September 27-30, 1926

Two papers on the subjects mentioned above were presented on September 28 at the Power Session of the Society's Old Dominion Meeting held in Richmond, Va., at which Vice-President A. G. Christie presided. In the first paper, William C. Bell, chief engineer and manager of the Virginia Electric and Power Company, Richmond, distinguished between the terms "superpower" and "interconnection," and outlined conditions under which interconnection of power-distribution systems are generally undertaken, the reasons for such interconnections, and the general forms and bases for contracts between the companies interconnected. Specifically the paper described the Virginia-North Carolina system under which the author's company operates.

In the second paper, R. S. Baynton, of the Chesapeake Corporation, West Point, Va., described a new power plant which he had designed in which boilers operating at 425 lb. pressure pass all steam through a turbine and exhaust into a steam header to supply the mills at 130 lb. pressure. These papers were published in the October, 1926, issue of Mechanical Engineering, pages 1036 and 1039, respectively. The discussion, which was extended, appears in abstract form below.

Interconnections in Virginia and North Carolina

R. S. Baynton,[1] who opened the discussion of Mr. Bell's paper of the above title, advocated coöperation and coordination between industrial plants generating their own power and public utilities, whereby the former would sell power to the latter. He mentioned as an instance, a large soap-manufacturing company which was at present burning about 600 tons of coal a day. If that company installed high-pressure boilers and utilized the exhaust in its plant, it would have surplus power over its requirements of probably 10,000 kw. that it could sell to utilities.

President W. L. Abbott called attention to the presence of a political tinge in superpower introduced by the fact that it was employed by people who were not always known as friends to the utilities as a public threat against the latter. Thus, the president of the Illinois Miners' Union and the presidents of other unions in Illinois had suggested a system of superpower to cover the state. This had not been taken seriously, however. The bare idea of a utility being obliged to depend for power upon the full production of a mine in such a place as Williamson County, Ill., with its town of Herrin, he said, was enough to kill the whole proposition. The relative amount of power which could be transferred between large plants by any reasonable connection was quite considerable. Arrangements were now available for power transmission between Pittsburgh on the east and Keokuk on the west, but while the line was large for local purposes, it would be entirely inadequate to handle the output of the large plants at either end and of some which were in the middle of it. Hence the helpfulness of inter connection between large centers at least was substantially negligible. Some hydroelectric plants should never have been built. Being built, however, and being remote from centers where the power was to be used, they had to be tied up with some system (this applied to the prairie states). As a rule the amount of power available from the comparatively low heads and the great cost of developing such power, rendered such plants commercially undesirable.

President Abbott cautioned utilities against relying upon surplus power from commercial plants and cited the case of his own plant in Chicago which tied up with a plant of some 3000 or 4000 kw. in the stockyards. The connection was not a happy one. The stockyards plant was busiest when the utility was. The result was that it could give its power to the utility at any time except when the latter wanted it, and could take power at any time except when the utility had an excess of it to sell. Furthermore, being equipped with induction motors and over-motored, the stockyard plant had a power factor which normally ran around 60 to 70 per cent, a circumstance not at all favorable to the utility.

The speaker added that he did not want to leave an impression that he was opposed to interconnection. On the contrary, he was heartily in favor of it and cited the fact that the largest example of it was in the metropolitan Chicago district where four or five companies of a capacity aggregating well over 1,000,000 kw. were interconnected and the interchange of power in that district was considerable.

In what he had said he was talking more against the non-technical, non-professional impression that it would be possible to transfer power for great distances between large companies. Within a limited district interconnection was the proper thing to do, and it operated to the very great benefit of all concerned.

Selby Haar[2] took up the question of the definition of superpower. He claimed that, as the author gave it, the distinction between superpower and other systems was not one between central generation and manifold distribution on one hand and local generation and practically no general distribution on the other. Mr. Haar own understanding of superpower was that it was simply a difference in magnitude over what had existed previously.

In his closure the author, Mr. Bell, said that he felt in regard to the purchase of dump power from industrial plants by utilities very much as did President Abbott. He would not deem it wise to purchase a relatively large amount of power from any industrial plant, because he would not consider it the proper thing to put any great dependence on its capacity. He believed, however, that as time went on a certain amount of power would be absorbed by the utilities.

[1] The Chesapeake Corporation, West Point, Va.

[2] Assistant Electrical Engineer, Board of Transportation, City of New York. Mem. A.S.M.E.

Coming to the question of definition, he stated that a superpower system did not necessarily mean common ownership and a common company. The word was more or less elastic. Some ten or twenty years ago a city like Richmond would have had a plant in Richmond to generate all the power that was used in Richmond. Now the superpower idea was that, rather than for the ten cities in such an area to have ten plants generating power, they would be grouped together and a relatively small number of high-efficiency plants would produce all the power used in that area.

The question of load despatching was frankly not a serious matter in Virginia, for the reason that the areas are relatively broad and the lines are of small capacity relatively. The company could take during certain hours of the day one or two thousand kilowatts as the case might be, and operation was carried on on that basis unless some trouble developed.

The operation of interconnecting systems so as to insure the proper distribution of load is a rather simple matter, and a simple governor control at the generating plants should take care of providing a definite amount of power transferred as desired.

In reference to buying dump power from industrial plants Mr. Haar cited the New York practice, which was, however, along somewhat different lines. The New York Edison Co. leased the power-generating stations of the Hudson-Manhattan Generating Co. and operated them as it saw fit. Possibly a utility might in a legal way lease the generating plant in an industry and also legally operate it. By the utility being legally responsible for the operation of the industrial power plant it could take such precautions as were needed to see that the supply of power thus obtained should be reliable enough for its purposes.

The Design of High-Pressure Industrial Power Plants

As a POSTSCRIPT to his paper on the above subject, Mr. Baynton remarked that while in many industries the cost of power was a very small proportion of the total factory cost, it should not be disregarded, because no matter how small it was, any savings that could be made became an addition to dividends. In all industries of any magnitude the cost of power was an item deserving consideration and in many cases it could be decreased, and this latter could be effected in a safe, certain, and sure manner.

In the discussion that followed, H. H. Snelling[3] asked why the electric CO_2 recorders used in the plant described by the author were not connected for air control to the heating instrument, so that as the demand was varied the CO_2 recorder would automatically throw out one heater. Where there were efficient new and poorer old boilers, the CO_2 recorder could be used to throw out automatically the poor boilers.

In reply to this question Mr. Baynton stated that the CO_2 recorders were used only for checking boiler meters also installed in the plant. Measuring as they did the air flow, the boiler meters would be completely upset if the gas passages should choke or the baffles leak.

F. A. Wettstein[4] attacked Mr. Baynton's statement that steam accumulators were essentially inefficient from a thermodynamic point of view. He claimed this was not so in plants where there were fluctuating steam demands and fluctuating pressures. In practically all industrial plants the fluctuations in pressure and steam did not coincide in time or in value with the fluctuations in power. The accumulator made it possible, if it was properly arranged, to equalize the demand for steam and the demand for power.

It was not generally realized how rapidly the efficiency of non-condensing turbines and of the high-pressure section of the bleeder turbines decreased with decreasing heat. This decreasing efficiency was very much more pronounced than the decreased efficiency of condensing turbines. By equalizing a system by an accumulator, the efficiency of the non-condensing turbine in generating power was so much increased that the loss which resulted by passing the small amounts of steam through the accumulator was more than compensated for. There were dozens of plants today equipped with accumulators where gains of 10 to 20 per cent, and in a few cases as much as 40 per cent, were obtained over the amount of non-condensing power which could be obtained without an accumulator.

The author had further stated in the paper that an accumulator was a rather expensive and cumbersome piece of equipment. Careful calculations had shown that if an accumulator was considered, from the beginning, in advance, as described by the author, the total costs for the plant including the accumulator would not be materially increased compared with the plant without an accumulator. In some cases the opposite was true; that was to say, the costs for the plant including the accumulator would be lower than for the plant not including the accumulator. This was due to the fact that with an accumulator the boiler plant needed to take care only of the average demand and the peaks were taken care of by the accumulator, and in this way considerable savings in the first cost of the boiler plant were obtained. Further, since the accumulator increased the output of non-condensing power, the size of the condensing boiler plant was reduced. In some cases the accumulator had made it actually possible to do away entirely with the condensing plant; and in these cases simple non-condensing turbines had been installed instead of the condensing turbines which would have been necessary without an accumulator.

In this connection Mr. Baynton stated that in the case which he had described where the fluctuations in steam demand were long he did not consider it advisable to install accumulators. Neither did he believe that the capital cost of a new plant with accumulators would be no higher than the cost of a plant without them, at least not in a case where the fluctuation extended over a period of time longer than that covered by the accumulator. He recognized, however, that the whole matter of the use of accumulators was controversial, and what he stated was merely his own opinion.

Howard Butt,[5] in commenting on the subject of air preheating, mentioned the fact that stokers were standing up under 160 deg. and that he knew of some cases where they had stood up under 300 deg. As far as he knew, preheated air was not injurious to the refractories or to the stokers.

Wm. W. Gaylord[6] called attention to the choice of high pressure in Mr. Baynton's plant so as to get a wide spread between the high-pressure and the low-pressure turbines, and asked what the pressure was at which he bled the moderate-pressure boilers and how much the total quantity bled off was; also whether it was done at one or more pressures. Apparently Mr. Baynton's plant was working for some industry where the demand for steam was fairly constant, possibly varying over a wide range. It might be harder, however, to apply to industries where it varied much more rapidly.

In reply Mr. Baynton stated that the choice of high pressure had been more or less definitely determined by the proportion of high-pressure and low-pressure steam required and the electrical load. A certain amount of variation was possible by choosing a turbine which had a higher or lower Rankine efficiency. That was not quite so foolish as it sounded. It was not necessary always to have a turbine of the highest efficiency but there was a certain amount of choice there. Why? It was the pressure at which the low-pressure turbine was bled and the quantities of steam which were taken off at the low pressure. Now bleeding was done in many ways—if one wished to define bleeding as the use of exhaust steam. Strictly speaking, the only bleeding done was of the low-pressure turbine, which was bled at 10 to 20 lb. for the pulp evaporators. This section of the plant had a very steady demand, going the whole time, which meant that very little steam was rejected to the condenser. There was reason to believe that the total steam rejected to the condenser would be about 3000 lb. per hour, or about 4 per cent.

As regarded the other points at which the plant bled, or at which it used exhaust steam, all of the engines exhausted at the different pressures required. The plant had a 300-hp. engine that exhausted into certain driers at any pressure required, and the condensate from these driers was returned to the boilers.

[3] Patent Lawyer, Washington, D. C. Mem. A.S.M.E.
[4] Chief Engineer, Ruths Accumulator Co., New York. Mem. A.S.M.E.
[5] Sales Mgr., Air Preheater Corp., New York. Mem. A.S.M.E.
[6] Westcott & Mapes, Inc., New Haven, Conn. Mem. A.S.M.E.

Another engine exhausted at from 20 to 30 lb. Each one exhausted at a different point. Another one which was exhausting at 30 lb. would be replaced by steam drawn from the bleeding turbine as soon as the motor drive was fixed up.

President Abbott, after pointing out that the plant described in Mr. Baynton's paper was unique in that it carried its back pressure as high as 135 lb., questioned the relative costs and relative operating cost including the overhead and capital charges as between the plant described and an arrangement wherein power would be bought from a utility and a straight heating plant provided with such accessories as would appear warranted. With a comparatively even load and a 24-hr. business the price for purchased current should be very reasonable.

Regarding this, Mr. Baynton said it would be too hard to answer such a question without a great deal of thought, and even then it would be hard to answer it definitely. Each individual case would have to be considered on its own merits.

John C. Robertson[7] also asked the author for information as to the operating-cost figures given in the paper, and whether they included the decreased efficiency of an obsolescent plant and its proportion of the overhead of the entire plant, as well as the length of time it took to become obsolete. He added that his company had 1000 hp. in Baltimore and the plant fluctuated in the use of steam. They figured they could buy power 2 cents per kw-hr. cheaper than they could make it. The only power taken out of the system was for heating in winter time with individual units placed throughout the plant. The circulation was obtained by air driven through a very small turbine connected on each meter. The steam passed through the turbine and then down the heating coil. Mr. Robertson also questioned the figure 0.19 cent per kw-hr., replying to which, Mr. Baynton said that he recognized that the value was very low, but it had been taken from a report he had had to make and that the cost had been arrived at carefully.

In a written discussion Harold Anderson[8] stated that in the arrangement outlined in the paper it seemed that the evaporators were to operate continuously regardless of the demand for 130-lb. process steam. As this demand was supposed to vary gradually from 44,000 lb. per hr. to 78,000 lb., per hr., it was suggested that the evaporators could be used to equalize these fluctuations. In other words, the evaporators would only be used at their maximum capacity when the demand for 130-lb. process steam was low and thus help to maintain a constant rating on the boiler plant. This scheme would require a larger evaporator installation than the present one and also a storage-tank system for the evaporated water, but this extra cost would be counterbalanced by the even supply of power obtained from the 130-lb. process steam. Under present operating conditions the condensing section of the bleeder unit had to operate when the demand for 130-lb. process steam was low, thus rejecting a certain amount of heat to the condenser. In the suggested arrangement the maximum amount of power would be obtained from the process steam and a minimum amount of steam would pass to the condenser. The steam which was ordinarily taken from the last effect of the evaporator for use in the heater could probably be obtained from the bleeder point of the low-pressure bleeder turbine, thereby retaining the present system of feedwater heating

Some cost figures, Mr. Anderson said, were given in the paper, but all of them referred to the cost of operation. It would be very interesting if the author would give some figures which would show the comparative costs of high-pressure and low-pressure installations, as actual cost figures of this kind were rather scarce.

Mr. Baynton answered Mr. Anderson's question as to evaporators by saying that they were used to equalize conditions to a considerable extent; that was to say, if it was found that for any single period of time there was likely to be such demand on the low-pressure steam that it was going to be more than usual, the evaporators could be shut down or throttled down. Three relatively large storage tanks of 18,000 gal. each were available which permitted storing water and using the evaporators to compensate for any variation in load. Mr. Baynton found the suggested use of larger evaporators objectionable. As regarded the figures of cost of operation, he stated that these figures were taken from the reports which were made to the management as to the results to be expected before the scheme was adopted.

W. G. Diman[9] contributed a written discussion in which he said that he thought the scheme worked out by the author was a very practical one and one which many plants requiring steam under the same conditions might well pattern. Nearly all industrial plants offered opportunities for utilizing waste heat or for producing power as a by-product of the process steam. There was a large field for this use today, a great deal of which was untouched. However, within the last few years much more interest had been shown along this line. When steam was used for power and the by-product heat for process work, and the heat in the spent liquor was utilized, there was not much more that could be done, and no power, when all charges were taken into consideration, could be produced at a cheaper cost.

In connection with this, Mr. Diman wrote, more thought should be given to the use of heat in the manufacturing process. Initial steam pressures were raised and exhausted at the turbine at a high exhaust pressure in order to satisfy the manufacturing conditions. The exhaust might be lowered in pressure if proper study was made of the manufacturing processes. This required the coöperation of the manufacturing end, which in some cases was hard to obtain, and was more or less natural as they did not want to take any chance with the manufactured product. This, he thought, must be done through proper education and experiments. Work now processed at a pressure of 100 lb. could probably be done as satisfactorily with 50 lb. or less. If advantage was taken of this there were greater possibilities to be obtained. When a study was made of utilizing by-product heat from a prime mover the whole situation should be taken into consideration, and the final pressure should be the one arrived at after all conditions had been analyzed.

Each proposition was a study in itself and required a great deal of analysis before any definite decision could be made. The question of the steam used, coördination of load and steam, reliability, and ease of operation were factors that must be definitely established. The prime mover to be used in the particular case depended on the plant conditions. Where sufficient power was available to cover breakdowns the best proposition was a straight non-condensing turbine floating on the line and furnishing power on the exhaust-steam demand. Sometimes an extraction-type turbine might be the best solution, but this in many cases was more or less of a compromise. The idea as worked out by the author was a very practical one and served the purpose of furnishing steam at various pressures without spilling much to the condenser. So far as the operation was concerned, there should be very little trouble as the machines themselves should easily take care of the ordinary fluctuations.

In connection with the use of high pressures Mr. Diman was rather interested in the question of reducing valves to bypass the steam from the boilers to the lower pressures in case of damage to the non-condensing turbine. With high pressure and temperature it seemed to him that trouble would follow in case such valves were used to any great extent.

Mr. Diman's comments called forth from Mr. Baynton the remark that while there was a possibility of trouble with the reducing valves, not much of it had been experienced thus far and they were probably much less of a problem than would be expected. As a matter of fact, he said, they were not much used. He did not agree with Mr. Diman's suggestion as to the possibility of obtaining exhaust steam by simply floating a straight non-condensing back-pressure steam turbine on the line. It could only be done if one were content to limit the steam supply according to the amount of electric power required. Mr. Baynton claimed that one could not float a straight non-condensing back-pressure turbine on the line, and that one must have either a high-pressure bleeder turbine or two turbines, one of them a high-pressure turbine and the other a low-pressure turbine running in parallel on the electric side.

[7] M.E., Locke Insulator Corp., Baltimore, Md. Mem. A.S.M.E.

[8] General Engineer, Westinghouse Elec. & Mfg. Co., So. Philadelphia Works, Philadelphia, Pa. Mem. A.S.M.E.

[9] Supt. of Power, Amoskeag Mfg. Co., Manchester, N. H. Mem. A.S.M.E.

Tropical Hardwoods with Special Reference to Their Use in American Industries

An Outline of the Problem and Details of a Program of Work for the A.S.M.E. Special Research Committee on Substitute Species for Domestic Woods

By MAJOR G. P. AHERN,[1] WASHINGTON, D. C.

THE position of one of our major industries in relation to its supply of raw material has recently been very forcibly brought to the attention of our Government and to that of the public. Almost every one knows that we are faced within three years with a shortage of crude rubber. The fact that in 1923 we consumed in the United States about 305,000 tons of rubber, valued at $185,000,000, and about 386,000 tons in 1926, at a cost of over 400 million dollars, and that in 1930 we shall probably require more than 500,000 tons, with little prospect of being able to obtain it, should cause much concern. Congress appropriated half a million dollars "to investigate and report on the possibilities of developing the rubber-plantation industry in the Philippines and Latin America," and the whole country has talked the matter over and speculated as to what we ought to do about it. This sudden activity and interest in the matter was due to two causes. In the first place, all of our rubber supplies are produced in foreign countries and in 1922 government restriction of production brought about a sharp rise in the price of the commodity. (There are at present governmentally controlled foreign combinations in nine raw materials needed in this country.) In the second place, every one uses rubber, and uses it in such forms that any change in the price is immediately and keenly felt by the ultimate consumer.

Every industry dependent upon the use of wood in any form is similarly threatened, and, in the aggregate, the present and impending shortage of timber supplies is a vastly more important problem than the rubber situation which has been, and is, receiving so much attention. Unlike the rubber industry, the wood-using industries of the country have drawn their supplies from within our own borders. We have long been the world's greatest producer of wood and wood products, and this position has, in a measure, blinded us to the fact that we shall, in the end, inevitably have to pay our own bills. Had the rapid and steady rise in the index price of certain of our woods been due to causes outside our own control, and the increased cost to the consumer been paid abroad, we would have been very much concerned and probably before now would have taken steps to protect the industries affected.

It is not the intention here, nor would it be possible within the scope of this paper, to discuss the timber situation of the country in its entirety. It will be sufficient if attention is drawn to the fact that we are cutting out our forest capital at a rate something over four times that at which it is being replaced, and that a general timber shortage is not a matter of the remote future but is already with us. Opinion interested in the present lumber industry of the country to the contrary, this is a fact that cannot be controverted. The effect of this shortage is not generally felt by the public as it is indirect and reflected in a lack of housing, increase of rents, and in a thousand minor ways. However, it is a different matter if we come to consider specifically the supply of certain timber species. More than thirty industries, ranging in their activity from the manufacture of furniture, vehicles, toys, etc. to firearms and airplanes, are largely dependent upon the supply of ten woods.

Statistics show that the production of white pine has fallen off from seven and a half to one and a half billion board feet; that the oak cut is now only one-half that of 1900; yellow poplar less than a third; elm only one-fourth; hickory and ash have fallen off; and an increased cut of red gum and birch has not kept the total cut from declining from fourteen and a half to six and a quarter billion board feet. No better evidence of the waning supply of these species than the above decline in production could be required.

The first and continuing effect of the shortage was rising prices. With this we are all familiar. It was accepted by the industries as a part of the general economic trend, and they have been prepared to pay what was necessary to obtain the material they required. But willingness and ability to pay will no longer meet the situation. As local supplies were exhausted, small concerns went out of business. Large and well-financed organizations, able to draw their supplies from distant sources, fared better, but they are now coming into competition with each other to an extent which threatens the existence of all. Centers of production have shifted following centers of supply until they are at their last stand. The furniture maker finds himself handicapped in competing with the maker of musical instruments, and the manufacturer of agricultural implements withdraws his buying organization from the field in times of stress because he can no longer compete with the manufacturer of vehicles and vehicle parts. Substitutes for wood have been tried wherever it has been possible to introduce them, and brought into use either at higher costs or to less advantage than wood. We are approaching the limit in that direction and it will not suffice to meet the situation. There is an irreducible minimum beyond which we cannot substitute for wood. The growing use of substitutes for wood tends to alarm certain of our producers, but a survey of all of our wood-using industries brings to our notice ever-increasing new uses for wood. As one investigator in the Forest Service remarked, "The age of wood may be *ahead* of us."

A New Source of Hardwood Supply

A new source of timber supply, especially of hardwoods, is required at once to check the drain on our fast-diminishing native supplies and carry us over the very considerable period which will have to elapse before we can, by replanting forests, put ourselves again in the independent position we occupied at the beginning of this century. Economically this necessity is of greater national importance than the future of rubber supplies, and deserves attention as such. More particularly it is of vital importance to the continued existence of some of our hardwood-using industries, and no one of them is in a position to be independent of it.

The forests of tropical America offer us the source to which we can turn in this emergency. They cover nearly 3,600,000 square miles of territory, of which about 3,000,000 square miles carry forests of broad-leaved species. The Amazon basin, in Brazil and neighboring countries, is estimated to contain 3400 billion board feet of standing timber, which is undoubtedly the largest continuous body of timber in the world. In all of tropical America there exists probably not less than 5000 billion feet.

These forests are closer to our ports than those of Africa, Asia, or Oceania. They are owned by countries which are politically and economically closely related to us and whose governments would probably look with favor upon and coöperate in their utilization. Capital within the holding countries is not available to take up adequately the work of development, and the resource awaits the interest of consuming markets. The world demand for timber increases, and inevitably this vast supply will be brought into use. Either we must take a hand in it ourselves or others will; and our hardwood-using industries will then be in a position similar to that of the rubber industry with themselves the world's greatest consumers and production largely outside their control. This is no remote possibility. A hardwood shortage was thought to be far distant in 1900, but it is with us now. Within the next two decades we may be compelled to import at least three to five billion board feet of hardwoods annually. With our own industries in control of production we may be able to meet our requirements at an annual cost of $250,000,000 or less, but if we leave to other

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Presented at the Wood Industries Division Meeting of the A.S.M.E., Chicago, November 23, 1926. For discussion see p. 46.

countries the control of tropical-American forests it may cost us double that sum, or "whatever the traffic will stand." It is a very great task, however, to increase the quantity of imported hardwoods from its present volume of 200 million board feet to even one billion feet; not so much in the production and marketing of the billion feet as in the disposal of approximately three to four billion feet of lower non-export grades remaining after high-grade material is produced. There is a limit to what local markets can absorb.

The idea of putting into use the timbers of the tropics is no new one. European countries holding large colonial possessions in the tropics have long recognized the value of their forests and have much capital invested in their development. They are keen to foresee Uncle Sam's needs for raw material long in advance, and prepare to meet them by giving encouragement and support to new ventures in their colonies. Patience was well rewarded in rubber and gutta-percha production; a longer period was necessary to produce pencil cedar in Kenya, British South Africa, which now promises to become the chief source of supply of pencil wood for all Europe, being raised at half the cost of American cedar. The Germans in Venezuela and the British in British Honduras and Ceylon are growing mahogany that within another twenty years will well repay the patience to wait fifty years to supply what promises to dwarf the rich returns per acre now obtained by rubber plantations. The forests of the Philippines have engaged the attention of our administration there, and under it a flourishing timber industry has developed. But although we are, by a very long way, the heaviest consumer of timber and timber products in the world, we have largely disregarded the great potential source of supply existing in the tropics of our *own* hemisphere. Our own great wealth of first-grade woods has acted in two ways to prevent us from drawing on the supplies of the tropics. In the first place, an abundant supply has hitherto been available at home, obviating the necessity of importation. Secondly, this same abundance has enabled us to specialize in the use of wood to an extent approached by no other country, and this specialization has developed a technique which is so rigid in operation as to exclude the utilization of any wood whose physical qualities are not well known. This specialization has proceeded furthest in the final utilization of wood, but it extends right down into the primary practice of logging and milling. Our great forest wealth has been the cause of its own destruction.

Having thus built up a great self-contained industry, it is now going to be the more difficult for us to adjust its machinery to the absorption of new material. This applies to some extent to the primary logging and milling operations as well as to final utilization. Were it not for this, the problem of obtaining and putting into use new supplies of raw material would be relatively of less importance. New woods could be brought into use gradually, in conjunction and interchangeably with the waning supply of native species. Both extraction and final utilization could be matters of slow development, and might have begun long since. But conditions did not and do not permit of this. If new material is to be utilized it must have the physical properties which both suit it to the final use of the manufactured article and to the standardized high-speed methods of manufacture. These properties must not vary greatly, and, most important of all, sufficient quantities of the material must be available to permit an industry to put it into continued use. If a wood in all respects the equivalent of the high-grade hickory and ash required in the manufacture of handles were offered the industry today it would, regardless of price, receive little attention unless steady supplies could be guaranteed. Price would then be a secondary consideration. Modern manufacturing and marketing methods absolutely preclude frequent shifts in even the external appearance of material used.

An Experience Worth Noting

Modern forest development in the Philippine Islands and the wider use of native woods locally and in the world's markets offer light on the problem before us today. For several years following the American occupation of the islands the vast bulk of building material for private and public construction was hauled across the great Pacific. Crude methods of logging furnished the local market with small quantities of the finer hardwoods at varying and uncertain prices. The heavy stands of lumber covering the 60,000 square miles of public forest were scarcely touched. The newly organized Forest Service made a rapid reconnaissance of the more accessible forests, found some 2500 to 3000 tree species, and as many as 900 species on one tract of 18 square miles. It developed, however, on investigation, and still holds good after twenty-odd years of development, that some twenty tree species constituted 80 per cent of the stand. The majority of the twenty species, the abundant woods, were not popular in the market. The wood were brought to the attention of the local and world's markets within a very few years as follows:

A timber-testing laboratory was established by the Philippine Forest Service, where a series of tests on carefully selected logs were run. A large and well-prepared exhibit was set up in which each specimen carried full information concerning the properties of the wood, quantities and sizes available, distribution, approximate cost of production, etc. A furniture factory, another activity of the Forest Service, showed the finished product. Timber concessions up to several hundred square miles in area were granted for long periods, under liberal terms. These concessions were granted to Americans, British, Filipinos, Chinese, and other nationals. These concessionaires with selling agencies throughout the world soon developed a world market. They are operating with modern equipment under strict official supervision. The forests are improved by cutting, and substantial revenues pay not only the cost of an ever-expanding forest service, but also a net revenue to the Government about equal to the sum expended for the maintenance of the Forest Service. In addition to the above, publicity is not neglected. It might also be mentioned at this time that we find today after more than twenty years of operation that sawmills are on the same sites established at the time the concessions were granted, that the concession areas are sufficiently extensive to warrant permanent operations, and that on each area a stable and growing local population helps to solve the labor problem.

A Program of Research

Taking the above facts into consideration, it is quite clear that the problem of opening up a new source of supply of hardwoods is one presenting a number of different sides, and rather beyond the ability of any one industry to cope with. It requires coöperation in support of a properly equipped organization to make the preliminary investigations as to sources of supply, and to conduct the researches necessary before new species of wood can be brought into use where they are required and in the quantities demanded. The Tropical Plant Research Foundation of Washington, D. C., has foreseen the necessity of such work and is organizing to undertake it. The work is approached with the following background of established fact as a basis:

a The depletion of the supply of virgin timber in the United States, especially of certain valuable hardwoods, makes it necessary to seek and develop new sources of supply.

b Eight to ten billion feet of hardwoods are needed annually by the wood-using industries of the United States.

c Hardwood stumpage has steadily risen in price during the last twenty years to a point where substitutes for wood, unsatisfactory in too many instances, are appearing in all industries using hardwoods.

d New sources of supply. The most available sources of supply for the American market will probably be found in northern South America, but investigations will not be confined to tropical America, for other tropical regions will also receive attention.

e Amounts available. Reliable data indicate that large amounts may be made available to supply the demands of industry in the United States for high-grade material, while lower grades will be absorbed by local markets.

f Suitability of new supplies. A large percentage of the tropical woods have been known and in use, either locally or abroad, for over 200 years.

g Accessibility of supplies. The forests from which these supplies are to be drawn lie along navigable rivers, in healthful regions with local populations accustomed to forest work. These timber lands are readily accessible to American and European trade routes, assuring favorable freight rates. Existing conditions offer opportunity for investigation, organization and development of new sources of supply on a scale sufficient to meet a substantial part of our needs.

The necessity for additional supplies of hardwoods is imperative, and there are sufficient data with respect to the forests to the south of us to indicate that they can meet our needs. The work to be done is to bring to the user in the United States the wood or woods he requires in the quantities necessary for him to standardize with it and keep it in continuous use. Broadly, this work can be classified along three separate lines:

1 **Analysis of wood needs to show:**
   a The specific properties requisite in the various industries
   b The quantities required by each industry and the extent to which native species will fail of meeting requirements
   c Range of prices within which new material must be supplied
   d Definition of qualities which new species must present to meet the requirements of various industries.

2 Field investigation in the producing field to determine:
   a The location of accessible bodies of timber
   b The quantities and sizes and determination of various species
   c How these species are being used at present
   d Primary costs of extraction and milling and approximate costs at which lumber of the various species can be laid down at American ports.

3 Laboratory investigation with tropical species available in quantity to determine:
   a Their definite structure and identification
   b Their mechanical and physical properties: strength, seasoning characters, workability, durability, etc.
   c The correlation of their determined properties with uses in the United States
   d Factory demonstration tests supplementing laboratory investigations.

On first consideration this may appear to be a field of work which must necessarily take years to cover and from which no immediate practical results can be expected. Such is not the case. The work will doubtless continue as long as there are new areas of forest to be examined and as new demands for wood arise, but it is practically possible to begin utilization immediately. The information required under the first heading is in existence and only needs collating. The work of the Forest Service, and especially of the Forest Products Laboratory at Madison, Wis., has resulted in the collection of definite information as to the specific qualities of woods now in use. Intelligent attention on the part of representative industries to a simple questionnaire will enable us to settle at once the important point under this heading, i.e., "definition of qualities which new species must present to meet the requirements of the various industries."

The second phase of the work, involving as it does investigations in the producing field, must necessarily extend over a period of years. However, this does not mean that no results will be forthcoming until the whole field has been covered. Contrary to general opinion, tropical forests, although they are botanically more complex than those of northern countries, are not, from a commercial standpoint, composed of hundreds of unrelated species. The bulk of the stand—75 per cent or more in most cases—is composed of a few species. Enough is already known of the general forest distribution to permit field investigation to be directed at once to the location and study of logging units where large-scale extraction can be initiated and quantity production established with a few species having qualities which will permit of their utilization in the industries of the United States.

This brings us to the third field of investigation, upon which will depend the success in application of the data collected by the other two. The history of the utilization of wood shows that the introduction of each new species has been a slow development; a tedious series of repetitions of the "cut-and-try" method. It is that which has held up the more general use of tropical timbers, and has left almost untouched the great storehouse of timber to the south of us. Large-scale production cannot commence while such methods of introduction stand in the way. The demand for new supplies of timber can no longer wait upon such slow development, nor is it now necessary to do so. Laboratory experimentation can determine definitely the mechanical, physical, and chemical characteristics of any untried wood, and definitely correlate the characters it presents with the uses to which it is suited. The Forest Products Laboratory was established to standardize our information with regard to our native woods, and is fully equipped to do the same for new woods introduced from elsewhere. Doubtless many of the hardwood-using industries can collaborate in such work, especially as regards certain specific and detailed uses. Results need not be delayed. Experimentation can begin within six months after the first parties enter the producing field, for the dominating timber species are already known for many areas, and carefully selected log samples can be shipped north at once.

Such in brief is the field of work lying ahead of research into the uses and available supplies of tropical woods. Along broad lines a general inventory of the forest resources of tropical America is aimed at to be carried out as completely as time and funds will permit. It is essential that this be tied up to definite reliable data as to the specific character and value in utilization of the dominant species. Concise estimates of stand and cost of extraction are essential to economic development and must be an integral part of the first work undertaken. Without losing sight of the broad field of research which underlies the whole problem, it is felt that definite focal points of forest industry must be initiated at once. These, by natural development, will become the broad channels necessary to the completer utilization which is necessary to meet our ultimate demands for a continuous supply of high-grade hardwood lumber and which the extent of the resource justifies.

The Cost

The cost of two field projects, timber testing, and factory demonstration tests, other research and chemical work, as well as the establishment of a modest information office, has been carefully worked out. A well-trained personnel is now available and sufficient progress has already been made to warrant assurances for substantial success if the modest sum essential to carrying out the program is provided. A two-year program has been outlined and presented to the A.S.M.E. Special Research Committee on Substitute Species for Domestic Woods. This program calls for the expenditure during a two-year period of a sum not to exceed $100,000.

It is respectfully suggested that the above-named A.S.M.E. Committee be encouraged to examine this program carefully and to report its recommendations to your Society and the various wood industries interested. If the program is approved it is also suggested that arrangements be made for close and continued coöperation between the Tropical Plant Research Foundation, the U. S. Forest Products Laboratory, and The American Society of Mechanical Engineers.

It is a matter of urgent self-interest to the wood-using industries of the United States that the program of constructive investigation outlined above be commenced at once. The information is needed in order that business plans for the immediate future may be made. It is likely that some tropical woods will be found suited to prompt adoption for certain uses, so that returns will quickly begin to flow in from the investment of funds which this program of work calls for; but in the main this proposal is an argument for foresight, for insurance of the immense capital invested in our wood industries against exhaustion of their raw material. Many of our greatest American industries will assure you that investments in research have been the basis of their prosperity.

Who will support these investigations of the woods of tropical America? Conceivably there are three agencies that might be employed:

1 The United States Government
2 The governments of the Latin-American countries
3 The wood-using industries of the United States.

The prospects of getting the work done by our Government are not bright. The U. S. Forest Service has sought with weighty arguments for several years to have authority and funds ($50,000 a year for ten years) granted by Congress, but no favorable action is in sight and further efforts in this direction have been abandoned. Appropriations are inadequate for work to be done at home, necessitating private funds for investigations in tropical woods to be carried on under this program in the U. S. Forest Products Laboratory.

The governments of the tropical-American countries will give some aid to the enterprise, but it will be other than financial, for they lack the money and the trained men to initiate and carry out the investigation. They will probably assist in providing labor and transportation for our field parties.

We come, then, to the conclusion that the wood users of the United States must support the work in their own interests. They can do

so effectively through their trade associations by contributions of a very small pro rata sum, and such action will assure to them an opportunity to get the work started promptly, and pushed forward along lines useful to the manufacturer, and will bring to the wood users the largest measure of practical benefits.

The Tropical Plant Research Foundation provides an agency affiliated with the National Research Council, staffed by experienced men, supported by the coöperation of state and national foresters, in friendly relation with Latin-American governments, and lacking only the funds to carry out the undertaking.

Discussion at National Meeting of Wood Industries Division

Aim and Scope of Research in Tropical Woods

Before opening the discussion on Major Ahern's paper, Chairman William Braid White said that every one was aware that all was not well with the supply of our raw material, but unfortunately it was almost impossible to gather a knowledge of the facts from the parties to the question. It was a well-known fact, however, from the point of view of such users of wood as the pianoforte and furniture industries, that quality and quantity of species, hard and soft, were not what they formerly were, while prices had been steadily going up and the question had arisen as to whether it might be possible to discover substitute species, where these species might come from, what their physical properties would be, whether it were possible to get them logged, cut, and delivered, and whether such species coming from outside the country would be commercially practical or not. Since it had been found that some industries in the woodworking field were being driven to importing species of lumber, something that they did not dream of doing fifteen or twenty years ago, it had been found that the only way to get the facts was, if possible, to institute a practical research into the matter, and to that end the Wood Industries Division had bent its best energies, and some months ago had been able to arrange with the main research committee of the Society to obtain an appropriation for a preliminary research into the question, with the expectation that if this research should develop in any practical way, that it might later be conducted on a much larger scale, perhaps with the coöperation with the industries involved. The preliminary work on this research, he said, had been carried on by Major Ahern.

Mr. Caylor of the Forest Products Laboratory said that it had been mentioned a number of times that there was need of information regarding tropical woods before they could be imported into this country on a large scale. This was very properly the work of the Government, but so far Congress had made no appropriation for the investigation of foreign woods and would undoubtedly not do so until the need for it was shown. On all sides there was complaint from manufacturers that they were having difficulty in getting the kind of lumber they wanted, and yet the best figures available on the subject showed that there was enough lumber in the country to last from twenty-five to one hundred years, depending on the species. These figures, however, did not show the quality of the lumber. It was felt that good-quality lumber was getting scarce, but there were no figures to prove it, and one of the first things that would have to be done would be to determine exactly what sizes and grades of lumber were getting scarce. When definite figures on these points had been obtained and placed before Congress, that body would be more apt to act favorably.

Mr. Shotmiller of the Bell Telephone Laboratories said that during the past year he had made a study of the subject and had come to the conclusion that there was reason for saying that both hard and soft woods were getting scarcer. The original stands of hardwoods probably comprised something like 500 or 600 billion feet B.M. and it was estimated that these had been reduced to something like 200 billion feet. If the consumption was about 10 billion a year, this meant roughly that the supply would be exhausted in 20 to 25 years. If one studied the curves of the prices of all the hardwoods, he would find that in the last nine or ten years the prices had at least doubled, and in many cases almost trebled. With the exception of red gum, it would be found that there had been a steady decrease in cut, every curve showing a dropping down. It was easy to explain regarding red gum from the fact that it would stand hard usage, and today with its great use in crates and boxes its production had gone up. That, however, was all the more reason for saying that the future would see a much more rapid drop in the production of red gum than in that of any other species.

It was said that there were great amounts of pine being grown in the South, but pulp mills and similar enterprises were buying up these stands and using the timber when still small in size and before it had reached the stage of timber selling. Looking at the picture as a whole, it would be seen that the future did not hold out a very promising outlook and that it was incumbent on the woodworking industries while they still had the chance to use the native high-grade hardwoods to investigate other sources of supply, and do something so that when the day came when our own woods had been consumed, they could be replaced with other woods.

Mr. Curran, who had cruised for tropical timbers in the Philippines, spoke of the possibility of securing, when our hardwoods were exhausted, everything we needed from those islands. The problem as he saw it was that the woodworking industries would need the kind of timber they have in the tropics sometime, and Major Ahern had outlined a program which was feasible and desirable.

In his rambles in the tropics Mr. Curran had secured at his own expense specimens of timber to be tested out. He had taken them to various woodworking industries who had tried them and said that the timbers he had submitted were quite satisfactory, but that they could not be procured in sufficient quantity. It was going to be easy to substitute for walnut and similar woods because the tropical woods were rich in varieties which give a fine finish, but when cheap woods were wanted in large quantities a study of groups of woods that were absolutely unknown to the American market would be necessary. The Brazilian and Argentine people knew their own woods, and for 200 or 300 years had been using the classes that were suitable for their purposes, and that information was available. Unfortunately, however, the woods that they were using were almost as scarce in those countries as hickory and poplar, for example, were here. The kind of woods that the people in the tropical countries wanted were not the kinds that were needed in this country. Our demands were for woods that could be handled easily in our woodworking machines, not the hard, durable woods that would resist decay and the white ant, which were the timbers prized in the tropics.

The thing to do, Mr. Curran concluded, was to appropriate a certain part of the funds that were available to the use of the Tropical Research Foundation, and ask our representatives in Congress to see that an appropriation equal to the sum that the industries would give was made available for Government investigation of those timbers when they were brought here. In this work they would have not only the assistance of transportation companies engaged in South American trade and of the governments themselves, but also of those who had already invested in those timber lands, all of whom were anxious to make a market for the timber in question.

Sash and Door Manufacture—Value of Paint Primers on Wood

In amplification of his paper on Sash and Door Manufacturing,[1] Sern Madsen stated prior to its discussion that he believed the sash and door industries were doing their share in conserving lumber. Their adoption of veneer construction for pine and fir doors made possible the use of a grade of lumber considerably lower than had been employed previously for that purpose. The clear lumber used in making the stiles for a single door was sufficient to make veneer for three doors made of lower-grade stock.

[1] Published in Mechanical Engineering, December, 1926, p. 1453.

The doweled construction now used instead of mortise-and-tenon construction permitted cutting all the cross-members of doors from 8 to 10 inches shorter than formerly.

In reply to a question by W. H. Rohr as to the thickness of the veneer used on doors, Mr. Madsen said that it was $^1/_8$ in. If thinner veneer were used the joints were likely to show up due to shrinkage in the core; also in sanding uneven or crooked work the veneer was liable to be worn through. On the other hand, if it were made any thicker it meant a waste of lumber. Some hardwood doors were made with veneer $^1/_4$ in. thick.

Replying to Mr. Catcher who opened the discussion on his paper, The Value of Paint Primers in Protecting Wood,[2] M. E. Dunlap said that the Forest Products Laboratory had given lacquer a trial and found that three-coat work had an efficiency of from 64 to 74 per cent. For protecting the back of oak paneling from moisture, one or two coats of an asphalt paint would suffice. A mixture of a bronzing liquid and aluminum powder was also very effective. This latter cost about $2.25 per gallon.

Replying to J. R. Watkins, Mr. Dunlap said that in regard to the statement in his paper that the nearest approach to moisture-proofing efficiency had been 98 per cent, this had been accomplished by means of a combination of varnish and aluminum leaf. This latter was about $^1/_{15\,000}$ of an inch in thickness. The coat was built up, starting with a filler, after which a foundation coat of varnish was applied, followed by a second coat which later was allowed to dry until almost dust free; after this the aluminum leaf was applied over the surface, to which it would stick and form a continuous metallic coating. Additional coats of varnish could be applied over the leaf to protect it. Aluminum leaf was not as difficult to apply as one might think. It had been used successfully on airplane propellers, and a propeller could be covered with it in about twenty minutes and then be ready for a second coat

Fuel Conservation in the U.S. Government Merchant-Marine Fleet

Discussion of Professor Seward's Comprehensive Paper on the Subject Presented at the Old Dominion Meeting of the A.S.M.E.

IN JULY, 1922, there were approximately 400 merchant-marine vessels owned by the United States Government being operated, with an annual fuel bill of approximately $35,000,000. The importance of conserving fuel and of developing the most economical methods of operation were so evident at the time that there was organized in the operating department of the Shipping Board a Fuel Conservation Committee which immediately gave those matters some very careful and constant study. Particulars of the methods devised and employed and of the results obtained were presented by Prof. Herbert L. Seward in a paper read at the Old Dominion Meeting of the A.S.M.E., Richmond, Va., September 27 to 30, 1926, and published in Mechanical Engineering of October last, pp. 989–998. The discussion evoked by Professor Seward's statements and his closure thereto are given below substantially in full.

Written Discussion

J. H. King.[1] Professor Seward has very clearly pointed out the work of one branch of the Government that is doing probably more than any other one thing to establish the American Merchant Marine on a sound operating basis. The Fuel Conservation Section under Mr. Carl J. Jefferson has accomplished a difficult and unpleasant task in a way that is producing a decided return in millions of dollars saved. Not only is this saving accruing to the Government, but the results have been so remarkable that privately owned steamship companies are already benefiting from the example set by this section of the Shipping Board.

The performance records of the various ships are of course entirely dependent upon the data obtained. The one source of possible weakness in these performance records is the accuracy of the data, and it would seem that there is a great field here for the installation of the various instruments so well known to land-power-plant practice for recording as well as indicating the various data required. Sufficient progress has been made by instrument manufacturers to assure their dependability on a ship at sea.

In regard to the work being done to increase the efficiency of the Merchant Marine by fostering the adoption of machinery that will tend to reduce the operating cost, the author mentions the work the Shipping Board is doing in developing Diesel engines and making actual installations on board ship.

It seems important to point out in regard to the ships now fitted with steam installations that are to be converted to Diesel engines that these ships are practically all war products. In the war emergency it became necessary in some cases to install machinery built by people of little or no experience, and also to depend upon people to operate the ships who also, in some cases, had very little experience. It is therefore not strange that some of these steam plants did not prove economical, and that the maintenance and upkeep charges were high on some other ships.

The writer understands that all of the ships selected for conversion to Diesel equipment were either fitted with uneconomical machinery or else the machinery was in such condition that the cost of repairing and reconditioning was not warranted. It will of course be evident that it must be misleading and of no real value to compare the past operating costs of such ships with the operating costs after being fitted with the most modern type of Diesel equipment.

No doubt it is not intended to convey the impression that the relative operating costs would be determined in such a manner. Of course, the real value of this investigation will be to bring out the actual investment cost and the actual operating costs of a modern Diesel installation, and not merely to show the difference in fuel consumption.

The members of the Society who are so familiar with the great economies being obtained ashore today with the use of high-pressure steam plants will no doubt wonder why such installations have not been tried afloat. So far as is known, the Shipping Board has not proposed to convert any ship to a high-pressure steam plant. However, such an installation would make a very interesting and probably valuable comparison with a similar ship fitted with Diesel engines.

It will be of interest to note that the first so-called high-pressure installations were actually used afloat, but the advantages of such pressures became so obvious that they were adopted by shore stations, which soon surpassed the marine practice. However, there is every indication that marine practice will soon adopt higher pressures, and although the steps must perforce be slow, there is no doubt that the higher economies to be obtained with higher pressure and superheat are giving the proponents of the Diesel engine considerable food for thought.

There is undoubtedly a field for the Diesel engine and there is no question of the low oil rates obtained. However, the initial cost of a Diesel-engine plant is much higher than an equivalent high-pressure steam plant. Furthermore, the cost of Diesel fuel is considerably higher than the cost of bunker oil for boilers. Therefore the investment charges and the fuel costs of the Diesel plant would both be greater than the corresponding costs of a steam plant.

Very careful studies of the possibilities of high pressures and high

[2] Published in Mechanical Engineering, December, 1926, p. 1457.

[1] Marine Department, The Babcock & Wilcox Co., New York. Mem. Society of Naval Architects and Marine Engineers; Civil. Mem. American Society of Naval Engineers.

temperatures in marine work have indicated that in a moderate-sized ship of about 5000 s.hp., a shaft horsepower may be obtained on approximately 0.6 lb. of oil. The current quotations on Diesel fuel are $2.50 both at Norfolk and New York, as compared to $1.75 for boiler fuel. This represents a difference of about 42 per cent in favor of the boiler fuel.

Comparing the results obtained with Diesel engines where a shaft horsepower is obtained on possibly 0.45 lb. of oil as compared with 0.6 or even 0.7 lb. per s.hp. with the high-pressure steam plant, the actual difference in dollars of operating costs is readily seen to show very little, if any, advantage for the Diesel engine. This, coupled with the increased cost of lubricating oil and the much higher investment charge with the Diesel engine, must appeal to the private ship operator.

All will recall Captain Walter McFarland's long-established rule for the relative cost of coal and oil fuel in a steam boiler. This rule states that "If the cost of coal in dollars per ton is double the cost of oil in cents per gallon, the fuel costs will be equal." It may be of interest to note that it follows from this that the fuel costs of a steam plant would be the same as the fuel costs of a Diesel plant when the cost of coal in dollars per ton is the same as the cost of Diesel oil in cents per gallon. This is based on the assumption of a Diesel-engine efficiency of 30 per cent and a steam-engine efficiency of 15 per cent, a fair assumption for a good triple-expansion engine, which is by no means the most economical steam unit. Therefore a Diesel-engined ship using oil at 6 cents per gal. (a 42-gal. barrel at $2.50 is practically equivalent to 6 cents per gal.) would have the same fuel cost as a steamship using coal at $6 a ton.

There has recently been completed abroad a Channel steamer using 500 lb. steam pressure and 750 deg. fahr. total steam temperature. This marks the first very high-pressure steam installation on board ship. Detailed results of the trials of this ship are not available, although the press reports that the trials have been most successful.

American shipowners are not far behind. The Southern Pacific Steamship Company has already laid down a ship using 350 lb. steam pressure and 250 deg. superheat, or a total temperature of 688 deg. fahr. It is anticipated that this ship, which will have 6250 s.hp., will operate at the rate of 0.75 lb. of oil per s.hp. The Bradley Transportation Company has just placed an order for a ship to have 325 lb. steam pressure and 281 deg. superheat, which equals 710 deg. fahr. total temperature. This ship will also have a modern stoker installation.

Considerable effort is being expended in experiments with pulverized fuel. This is of especial interest in view of the rather startling information in regard to our oil resources contained in the recent report of President Coolidge's Federal Oil Conservation Board. If pulverized coal can be practically applied at sea, satisfactory fuel economy can be obtained and at the same time the drain on our oil resources will be lessened.

The successful application of pulverized coal will provide another advantage in favor of the high-pressure steam plant, since such a plant could be readily changed over from oil to coal if oil fuel became too costly or the supply inadequate. A Diesel-engined ship would, of course, be dependent upon oil, no matter what it cost.

Chas. F. Bailey[2] and H. C. Berrian.[3] The question of fuel conservation on merchant vessels is one of peculiar interest to the marine engineer and shipbuilder. In these days of intense competition for the meager amount of shipbuilding work available, the question of fuel consumption is an ever-present one. Scarcely a contract is signed in which there is not a fuel-guarantee clause involving a heavy penalty for poor performance.

The Newport News Shipbuilding and Dry Dock Company, in common with other shipbuilders, is particularly interested in this subject and the complete and exhaustive analysis which the Shipping Board has prepared. In the past, usually the most reliable information available has been that obtained on the builder's trial. On these trials the data are taken by the employees of the builder under conditions more or less controlled by him and the results worked up by the builder. Quite frequently either no builder's sea trial is specified or else it is finally omitted on account of the additional expense involved. After the ship leaves the builder's hands all data as to fuel consumption come from the chief engineer of the vessel as interpreted by the superintending engineer or sometimes the owner's consulting naval architect.

[2] With N. N. S. & D. D. Company. Mem. A.S.M.E.

[3] With N. N. S. & D. D. Company. Assoc-Mem. A.S.M.E.

One of the main difficulties lies in separating the sea consumption from the port consumption. The fuel-oil soundings are usually taken in port either on arrival or on departure, and the chief engineer makes an allowance for port consumption.

Quite frequently the owner's engineers work out the fuel used at sea on a horsepower-per-hour basis and these results are liable to be misleading, due to the fact that the estimated or measured power is sometimes taken too high.

One of the greatest variables in the total fuel consumption is the amount of steam required by auxiliaries. Great stress has been laid in the past on the performance of the main engines or turbines, but comparatively little attention given to the efficiency of auxiliaries. On a coastwise ship where the auxiliary steam consumption approximates 25 per cent of the main-engine consumption, this is a most important factor. Changes in design of auxiliaries have in many cases shown a marked improvement, but in the final analysis it becomes a matter in the hands of the operating personnel. Close attention to the operation of the individual units, particularly where conditions vary greatly (as on a run from New York to Florida, Cuba, or South America) is the only method of keeping down the auxiliary consumption. In this connection credit should be given Messrs. E. A. Stevens[4] and H. E. Brelsford for their contribution to the knowledge regarding the steam consumption of auxiliaries.

As mentioned in the paper under discussion, probably the most prolific field for improvement in fuel consumption is the boiler room. The engineer officer of one of our largest battleships has stated that he has practically ceased to look for further improvement in the engine room and is giving all of his attention to the fireroom in order to better the fuel consumption of his vessel. Here again (assuming that the proper boilers, burners, and draft equipment have been installed for the given conditions) success or failure lies almost entirely with the operating personnel. Undoubtedly the fuel-oil school operated by the Shipping Board has aided and will continue to aid in materially improving the efficiency of the boiler-room operation. The installation of smoke detectors and the information furnished the ship's engineers regarding fuel-oil viscosity will be of great service.

Among the ship performances shown in Fig. 12 is that of the *President Jackson*. This vessel was built at Newport News under the name of *Silver State*. From the results of the builder's trial it was evident that the machinery was exceptionally efficient. The water rates of the main turbines checked closely with the calculated figures. It is gratifying to find that the report given in this paper indicates that the service performance bears out the promise of the trial trip.

The ultimate unit of measurement which the Shipping Board has adopted, that of "miles per ton of fuel," or its equivalent, "pounds per knot run," has the advantages of taking into account the performance of the propeller and the efficiency of steering.

The sample reports given in the paper are most complete and comprehensive. In order to obtain all of the information summarized in these inspectors' reports the engine-room log sheets must be particularly complete. Right here is one of the reasons why it is so difficult to get reliable information in regard to ships in service. Unless the log-sheet form be complete, all the necessary information will not be entered by the ship's engineers. Sometimes the data are omitted, even though they are called for as items in the form.

It is gratifying to know that some private owners as they purchase Shipping Board vessels—and before, in fact—see the importance of these aids furnished by the Government and substantially adopt them with minor modifications to suit the individual cases.

The upkeep of the machinery is a vital factor in the operation of the vessel. In some instances, due to improper handling, the condensers and boilers have rapidly deteriorated, causing heavy expenditures for replacements and loss in service; in other cases,

[4] Water Rates and Steam Consumption of Auxiliaries, by E. A. Stevens, Jr., and H. E. Brelsford, *Marine Engineering and Shipping Age*, vol. 29 (1924), pp. 427, 492, 547, 611, and 676.

owing to poor design and construction, the burden of upkeep is heavy. It should be noted, however, that the latter is not due to neglect on the part of the officers. To fairly differentiate between these causes is sometimes a difficult problem.

One of the most important points in the paper is that the Shipping Board through its fuel-conservation program is bringing home to the operators the necessity of keeping close watch on the fuel consumption of their vessels, not only from a standpoint of barrels of oil or tons of coal consumed per annum, but also in respect to the component parts which go to make up this total fuel, particularly the fuel consumption in port as distinguished from that at sea, so that the points where efficiency can be improved are easily seen instead of being hidden in one unenlightening total.

Fuel-oil-burning, experiments and research in the use of pulverized coal, and the installation of Diesel engines for marine propulsion present live problems for consideration by marine people. The recent noteworthy advance in each of these lines is gratifying and illustrates the substantial aid which the Government can give to industry when there is need for such aid. This is particularly true when business interests coöperate to assist in and take advantage of such governmental research.

R. D. Gatewood.[5] The wise discretion, sound judgment, and tact shown by Mr. Jefferson in handling the many variables arising in the establishment of standards of many different classes of ships on thirty or forty different runs handled by three or four hundred different chief engineers can be fully appreciated by those who listened to the presentation of this paper. I would like to emphasize that the standards that have been set up are not at all theoretical or academic but are thoroughly practical ones, and there is not a single standard that has been set for a class of vessels that some vessel or vessels of the class are not actually meeting, and, better still, there is not an engineer in the Fleet who complains that the standards are unfair or unattainable. The importance of this from the human side is really very great and it serves as much as any one thing to keep the men constantly striving to arrive at something that they know can be reached by constant vigilance and attention and hard work, but not otherwise.

What the writer would now like to see would be this same method of attack applied to the other operating expenses of our vessels, such as wages, stores, equipment, stevedoring, etc., all of which represent sources of heavy operating expense, but all of which are entirely subject to comparison immediately after each voyage with certain definite standards which could be combined by the use of various arbitrary factors for the purpose of arriving at a definite figure that would indicate with a reasonable degree of accuracy the operating efficiency of the vessel as a whole and, what is more important, would give the executives in charge of the operation at least *relative* data showing how each vessel compares with other vessels of her class. These data when once provided on individual vessels could then be used to determine the relative operating efficiency of the various managing operators that are now being paid substantial commissions for operating our Government vessels. There is probably nothing that would improve the operating efficiency of our Fleet more than to apply to the other souces of operating expense the same treatment that has been so successfully applied to the program of fuel conservation.

Oral Discussion

In opening the oral discussion that followed the reading of the written communications, R. L. Daugherty,[6] referring to the statement in the paper that the relation between temperature and viscosity of fuel oils could be represented on the chart of Fig. 14 by a series of straight lines all intersecting at the single point *A* shown thereon, said that, while for the purpose of boiler-room operation this might be sufficiently correct; nevertheless, these lines were not straight lines, but slightly concave to the right, and they did not intersect in a common point but in a zone whose size on the scale of the chart might be roughly said to be a circle the size of a dime. The chart, therefore, should be understood as showing the relationship between temperature and viscosity only in an approximate way.

[5] Fleet Corporation, New York.

[6] Professor of Mechanical and Hydraulic Engineering, California Institute of Technology, Pasadena, Cal. Mem. A.S.M.E.

John Martin,[7] said that the author had brought out rather an interesting point in the fact that between pilot stations it was necessary to use one unit and in port another. He thought after getting into harbor there were so many other factors which entered into the consumption of oil that no accurate record could be kept. As an evidence, the *William Penn*, which had the first four-cycle Diesel engine installed in 1910, used 0.35 lb. of fuel per hp-hr. on her 3-day trial trip. This did not include any cargo handling. After two successive trips to the Orient, Mr. Olson, who was then chief engineer of this vessel, had assured Mr. Martin that at sea for all purposes the consumption ran about 0.36 lb., exceeding very slightly the trial-trip performance, but in port had been much greater than that for all purposes, such as cargo handling, etc. There had been difficulty in the Orient in 1921 and later, particularly on long voyages there, with Shipping Board vessels on account of fuel running short. Also the fueling stations were farther apart in Europe than in this country and sometimes it had been necessary to tow the vessels in some places for they had run short of fuel, say, a hundred miles from port. In the Orient, where the fueling stations were not as yet very well assured, and where they were more or less experimental, Shipping Board vessels and many others had to carry fuel for round trips. That would be done away with if the purpose of Professor Seward's paper was attained, and it would be more remunerative if it were possible to have more cargo space to sell both coming and going.

E. E. Hunt[8] said that a number of matters had been suggested by the reading of the paper, such as the desirability of better recording instruments and methods in the accumulation of data. He was curious to know just how all of the various factor weights had been arrived at so that the formula finally represented a comparable figure. Further, he wondered whether a ship was always compared with others in her class, whether the rewards for the engineer and for the captain were given class by class or on the basis of some weighted result for the fleet as a whole. How much had been done in the accumulation of information regarding the various grades of coal? What weight was given to the fact that ships coaled in all parts of the world and had to take on widely differing types of fuel? In that connection, too, the question of the performance of pulverized coal was exceedingly interesting and important.

Wm. Elmer,[9] speaking of the railroads' consumption of fuel, said that the basis on which coal consumption records were kept was the final work that the railroad did, i.e., the ton-miles per hour or pounds of coal per thousand gross ton-miles. Those figures in the last few years had been very carefully watched by all the operating officers, including those in the motive-power department, and they were constantly being urged to do everything possible to reduce the expenditure of coal. The condition of the engines, so far as the tightness of the valves, the setting of the valves, the insulation of the cylinders, the lagging of the boiler and steam pipes, the popping of the safety valve, the method of firing the coal by the firemen, the using of the steam by the position of the reverse lever and throttle on the part of the engineer, were all being given attention, and it was very gratifying to know that the effort that had been made had produced some very remarkable results. He believed that as a result of Professor Seward's paper a very gratifying reduction in the amount of coal used in the nation's shipping would ultimately come about.

Author's Closure

The Author. In closing the discussion of his paper the author wishes to thank those who participated therein for their complimentary remarks, and also to explain that the paper is really in the nature of a report to the Society, inasmuch as the author was its representative on the Fuel Conservation Committee for some time.

Mr. King's remarks about the need of more instruments on board marine power plants for the purpose of securing more accurate data, call to mind the difficulties of introducing much of this equipment.

[7] American Bureau of Shipping, Newport News, Va.

[8] Secretary, President's Conference on Unemployment, Department of Commerce, Washington, D. C. Mem. A.S.M.E.

[9] Special Engineer, Staff of Chief Engineer, Pennsylvania R.R. Co., Philadelphia, Pa. Mem. A.S.M.E.

The author feels that the data secured by the Fuel Conservation Section are accurate to a remarkable degree. Fuel soundings are taken by the Section's inspector at the end of every voyage. The marine power plant has such a steady load that when weather and draft of the vessel are known the standards of performance now set up by the Committee require the operating force to maintain the best temperatures, vacuum, etc., in order to "make the grade," although there may occasionally be some carelessness shown in entering these quantities in the log. Instruments which give to the operating force an indication of the one best fuel-oil temperature, air supply, etc., are more needed than the recording type of instrument. If standards are correctly set, the measurement of the fuel oil burned on the voyage will be the most important measurement of the overall economy of the plant. It is hoped that Mr. King's references to the comparative cost of Dieselized vessels and to high-pressure steam plants will stimulate us to secure the answer to these important questions from actual experiences in the near future.

Mr. Daugherty's comments about Point *A* in Fig. 14 prompt the author to state that in his mathematical paper given before the Society at the 1925 Annual Meeting, he developed the use of all sorts of logarithmic coördinates and was, of course, familiar with the fact that point *A* could only be a zone rather than a mathematical point. However, the introduction of any device which is simple enough for the marine engineer to use regularly in determining the one best fuel-oil temperature will be a most welcome device, and while this method (Fig. 14) is not possessed of the greatest academic accuracy, it is proving very useful and acceptable.

Mr. Martin has mentioned the M.S. *William Penn*. The data for setting some of our port standards for cargo handling came from this ship because of the ease with which wattmeters could be introduced to measure winch power. In regard to the towing of vessels to port in the Orient which had run short of fuel, many questions were involved. The Board naturally wished to give the operators as much operating power as possible and for a time did not supervise their bunker schedules. It soon became evident, though, that an official of the Board should supervise those bunker schedules, and it is the invariable rule now that a vessel must come in with between twenty and thirty per cent excess fuel, and the engineers are slowly learning that they must make that allowance. Whether or not to carry that fuel or purchase it abroad is a very different question, and still very difficult to solve.

In regard to Mr. Hunt's question, particularly about the importance of better recording instruments as mentioned by Mr. King, our real difficulties lie with the training of the personnel.

As to the question of whether the performance of a ship is always measured by the performance of a sister ship, the author would say that within the limits of reasonable comparison, it is. The advantages of competition between ships for increasingly better relative performance are secured, but the Committee naturally does not award a bonus to the ship which fails to approach the performance set by our absolute standards, although she may be the best in her class. The subject of stevedoring and cargo handling has been given much study. The newer ships and the reconverted ships are being fitted with much better gear for handling cargo, but the subject will stand a tremendous amount of analysis and revision of tradition.

The application by Mr. Elmer of the general ideas presented in the paper to locomotive practice is very interesting. Because of the short runs and because his power plant is on land, the locomotive engineer is under much closer supervision than his brother the marine engineer, so that any training of personnel ashore is bound to progress more rapidly and with more definite results than at sea. The marine engineer must first make his plant operate, and he has shown much resourcefulness in meeting the emergencies of operation. When we can give him a thoroughly reliable plant, maintained to best advantage, he will then turn his attention to economy and conservation.

The author desires to join Captain Gatewood in endorsing the very splendid work done by Mr. C. J. Jefferson in carrying out the policies and methods of the Committee.

Ultimate Strength of Single-Vee Welds

RESULTS of a series of engineering tests become of more general application, and acquire a higher degree of accuracy, as the influence of accidental variations becomes submerged in a great mass of data. To know something about the skill of 100 welders is of much more value than to know that an occasional workman can do excellent work. Averages of results gathered from 50 shops scattered all over the United States are almost sure to eliminate the influence of sporadic variations in practice, one way or another. Continual testing over a period of years prevents the possibility that the workmen were keyed up to unusual efforts.

Such a test (almost ideal) has been completed by Union Carbide & Carbon Research Laboratories, New York. Operators employed in various railroad shops in the country, 75 or 80 in number, were tested at intervals. From 1920 to 1923 the welding rod used was that known commercially as "Norway Iron," really a first-class low-carbon steel. During the last three years a rod known as "high-test rod" (containing about 0.20 per cent carbon, high in silicon and manganese) was the standard.

How the Welds Were Made

Pieces of plate about a foot long were taken from railroad stock and welded in the course of regular work with a single-vee butt weld. The plate then was sent to the laboratory, where it was cut into strips, all reinforcement ground off so that the weld was equal in thickness to the plates it joined, and the strips then pulled apart in a tensile testing machine.

The early three years on Norway iron showed that only about 11 per cent broke the plate, which was supposed to be of good quality, and which actually averaged 53,000 lb. per sq. in.

In later work on high-test rod, it was found immediately that only the best of flange steel should be used for test metal; even so, nearly half the specimens broke the plate rather than the weld. An illustration in the original article shows without doubt the influence of high-quality welding materials. Men of all grades of ability are able to increase the strength of joint by some 11,000 lb. per sq. in., merely by using better welding rod. Since the least skilful man is the shop's weakest link, so to speak, this is a most important consideration.

Determining the Proper Strength Figure for Design

One question yet remains to be answered. From this mass of data, what figure should be selected as representing the average tensile strength of weld metal, a safe figure to use for design purposes? It would be as unfair to use the lowest value reported as it would be to use the highest value, or for that matter to assume that firebox quality steel should be figured at less than 50,000 lb. per sq. in. (since one of these test specimens broke the plate at that low figure).

Mathematicians answer such questions as these by replotting the data in the form of a "probability curve." The number of test pieces which fall within a certain range are plotted vertically at a distance to the right representing the mid-point of the range in question. The peak of such a curve represents the most probable value; if it varies much from the theoretical shape, its form suggests undue influence of disturbing factors.

It would appear that the expected strength of single-vee oxy-acetylene welds, all reinforcement ground off, and made by operators selected with reasonable care, is as follows:

Using Norway iron welding rod, 47,000 lb. per sq. in.
Using "high-test" welding rod, 58,000 lb. per sq. in.

The factor of safety selected from each individual design would take into consideration the poorest joint in the lot. But, for either variety of welding rod, this is well above the elastic limit of low-carbon steel suitable for welding. Therefore, elastic limit of the base metal would be the ruling consideration in the selection of a factor of safety to apply to the ultimate strength of the joints described.—*The Iron Age*, Dec. 9, 1926, p. 1620.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS (See also Internal-Combustion Engineering: The Exhaust-Gas Turbine)

The "Lizette" Sport Plane

DESCRIPTION of a new low-powered two-seater plane for sport touring. This machine was designed by Roy G. Miller and Dayton T. Brown and was built by the Ludington Co. of Philadelphia. It is a parasol monoplane with semi-internally braced wings. The number of parts exposed to the wind stream has been reduced to a minimum, and further reduction of resistance has been obtained by the employment of streamline shapes. The fuselage is of duralumin with monocoque construction with the streamline form. The plane is powered with an Anzani motor rated at 35 hp., and weighs 850 lb. It is claimed to have a range of speed from 91 to 42 m.p.h., and a mileage of 38 miles per gallon at a speed of 65 m p h. (*Aviation*, vol. 21, no. 22, Nov. 29, 1926, pp. 918–920, 4 figs., *d*)

The Seaplane "Southampton"

THE Aviation Works, Ltd., founded in 1913, have specialized in the construction of seaplanes of the flying-boat type. The *Southampton*, which seems to have met with very favorable reception on the part of the British Air Ministry, belongs to this type. It is equipped with two Napier Lion engines and incorporates a somewhat unusual feature of being able definitely to fly and maneuver with one of its two engines stopped. The *Southampton* is a flying boat with a two-stepped circular-section hull of the flexible Linton-Hope type, the steps being built on as a separate structure. The whole machine was designed with a view to eliminate "blind spots," i.e., areas blanketing the gunner's view and field of fire. The manner in which the usual blind spot behind the tail has been avoided is particularly interesting. To begin with, the tail was designed as a semi-cantilever, the supporting struts projecting but a short way out from the tail. Secondly, the cockpits for the aft guns are placed as far out as possible laterally, and staggered in relation to one another, so that from one or other of the two cockpits there is no blind area beyond a distance of about 50 ft. from the tail.

Another feature of the *Southampton* is that no gasoline is carried inside the hull, the main gasoline tanks being supported under the top plane. In consequence the hull itself is practically free of obstructions, and in fact it is possible for members of the crew to walk about freely anywhere from bow to stern. There is even ample space to sling hammocks for the crew, who can and do thus sleep on board. The total weight of the *Southampton* is 14,300 lb. When used as a bomber the machine carries a crew of four (720 lb.) and 2130 lb. of armament and military equipment.

The *Southampton* has been in use by the Air Ministry for over a year and a number of flights were made, among others to Egypt and back. Also a flight from Plymouth to Aboukir and back, the latter a total distance of some 7000 miles. The machine was not described previously, however, as it was on the Air Ministry's "secret list." (*Flight*, vol. 18, no. 46/934, Nov. 18, 1926, pp. 744–749, illustrated, *d*. To be continued)

The Exhaust-Gas Turbine

OF THE two articles here abstracted (both by the same author) the first deals with the general principles of the exhaust-gas turbine, and the second with exhaust-gas turbines for the special purpose of supercharging on airplanes. Of particular interest to American engineers is the description given of the Lorenzen (Berlin) exhaust-gas turbine supercharger. Here the turbine rotor is utilized simultaneously also as an impeller for compressing the air, the latter flowing through passages in the turbine blades in a radial direction. This produces an effective cooling of the rotor, the operating temperature of which is only between 300 and 400 deg. cent. As a result of this, after 50 hours of running the rotor shows no traces of burning by the exhaust gases and there is no difference in the condition of the entrance and exit edges of the blades. The color

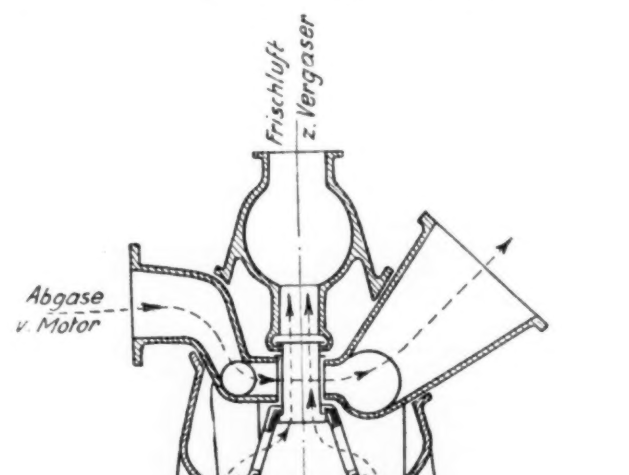


FIG. 1 LORENZEN EXHAUST-GAS TURBO-COMPRESSOR
(*Abgase v. Motor* = exhaust gases; *Frischluft* = air; *Frischluft z. Vergaser* = air flow to carburetor.)

of the rotor is not affected, and there is no loss of weight in the blades.

An extremely simple method (not described) of making the turbine blades from a special alloy-steel sheet material has been devised. The cooling effect is, however, said to be not the only advantage of this type of design. Both bearings of the rotor shaft are in the path of the stream of outside air coming in, and therefore have a reasonable operating temperature. The temperature of the housings (made of electron) is also low, while the spiral nozzle chambers leading to the nozzles, which have to be quite hot, are free to expand. Furthermore, the fact that only one rotor is used reduces the windage losses as well as the weight. The most important fact, however, is that because of the very short distance between the centers of the bearings, the

FIG. 2 SIDE VIEW AND TOP VIEW OF RUNNER BLADES OF THE LORENZEN EXHAUST-GAS TURBINE
(*Düse* = nozzle.)

critical speed is so high that it is not attained even at the highest speed of rotation of the device. (A. E. Thiemann in *Der Motorwagen*, vol. 29, no. 28, Oct. 10, 1926, pp. 661–671, 26 figs., *d*)

ENGINEERING MATERIALS

Copper-Beryllium Alloys

Two metallic substances that may be expected to be of use are now coming into prominence, namely, the elementary metals beryllium and germanium. The last is still only looming on the horizon. Certain zinc-producing concerns can supply its oxide at a price of, say, $5000 per lb., which the author sarcastically describes as reasonable. Beryllium has already dropped to something like $200 per lb. in the United States, and probably it does not cost more than $50 on the continent of Europe. Beryllium quickly brings down the melting point of copper. A 4 per cent beryllium alloy melts at 860 deg. cent., which is 224 deg. below the melting point of pure copper. The first crystals freezing out from the mold containing below 4 per cent beryllium represent a solid solution of beryllium and copper. The author describes the constitution of the copper-beryllium alloys in some detail and illustrates it by his own tests.

The following information is given as to the influence of beryllium upon the mechanical properties. Beryllium, to the amount of 1.2 per cent, increases the strength and yield point by 50 per cent, i.e., to 48,000 and 17,000 lb. as annealed. The ductility is not affected at all. The original article gives data for the strength of the same alloy cold-rolled and for an alloy with 1.7 per cent beryllium (55,000 lb. tensile strength, 22,000 lb. yield point and 50 per cent elongation in 2 in.).

At higher percentages of beryllium content, material changes in mechanical properties begin to appear. Thus 7.5 per cent beryllium alloy shows a hardness fluctuating between 350 and 420 Brinell. Chilled cast alloy ingots also show these figures. The 4.3 per cent beryllium alloy also crystallizes as a pure beta. It starts however to precipitate the alpha somewhere about 760 deg. Quenching the cast alloy from 800 deg. eliminates the continuous precipitation of the alpha, and the latter takes place in a visible form only at the grain boundaries which look very much like troostitic spots in steels. The grains themselves do not, however, represent a fully preserved beta. Their hardness is way above 200 Brinell.

The 4.3 per cent beryllium alloy stands hot forging and rolling easily. Hot-rolled and slowly cooled from 840 deg., it develops a structure nearly identical with that of a 10 per cent aluminum bronze.

The alpha (bright) of the hot-rolled alloy has a tendency to grow, and an eight-hour treatment at 500 deg. roughens the structure. But even under these conditions not much resolution is noticed within the grayish eutectoidal ground mass.

The mechanical properties of the hot-rolled 4.3 per cent beryllium alloy were studied only as quenched from 750 deg. They are: 126,000 lb. ultimate strength, 4 per cent elongation in 2 in., 197 Brinell, 53 Shore (universal hammer), and 15.9 microhms per cu. cm. specific resistance.

The hot alloy is very soft. It becomes hard and highly elastic but not brittle on quenching. The latter, if done at 800 deg. or so, would probably result in a higher ductility and a lower hardness.

Copper-nickel-beryllium alloys have been made and tested, but do not appear to be of interest to mechanical engineers. (M. G. Corson, Consulting Engr., *Brass World*, vol. 22, no. 10, Oct., 1926, pp. 314–320, 27 figs., *e*)

FUELS AND FIRING

The Meaning of Specifications for Gasoline and Kerosene

THE author tells first briefly the changes in gasoline and kerosene brought about first by the discovery of western and southern oilfields, and next by the huge demand for gasoline as compared with the much smaller demand for kerosene. He then proceeds to examine the Federal specifications for gasoline and kerosene and does it in a more or less critical manner. The paper is of interest to all those dealing with specifications for these fuels. (A. J. Kraemer, Asst. Petroleum Chemist, Bureau of Mines, in a paper presented before the National Conference of Gasoline Tax Administrators and Oil Inspectors, St. Louis, Mo., Nov. 11–13, 1926; published as *Information Circular* No. 6013, Nov. 19, 1926, *Department of Commerce, Bureau of Mines, g*)

Fuel Sizing for Chain-Grate Stokers

THIS article is intended to show the importance of proper fuel sizing for chain-grate stokers. The curves shown in Figs. 3 and 4 were plotted from data obtained from a large number of evaporation tests in which the coal-sizing conditions were taken into account, and they show clearly how the sizing of the fuel affects the ashpit loss. By ashpit loss is meant that part of the combustible in the coal which was not completely burned and has passed over the end of the stoker into the ashpit along with the refuse.

Referring to the curves shown in Fig. 3, each having the same rate of fuel consumption, the tendency is toward higher ashpit losses as the coal increases in size. For instance, coal with 10 per cent over 1 in. will give a loss of about 1.3 per cent, while a coal with 10 per cent over $1^1/_2$ in. will give a loss of about twice as much. In comparing these curves the critical size is directly shown to be less

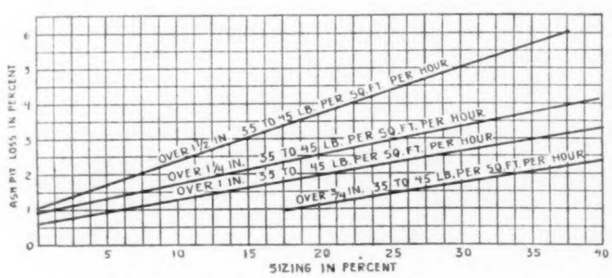


FIG. 3 RELATION OF ASHPIT LOSS TO SIZE OF COAL

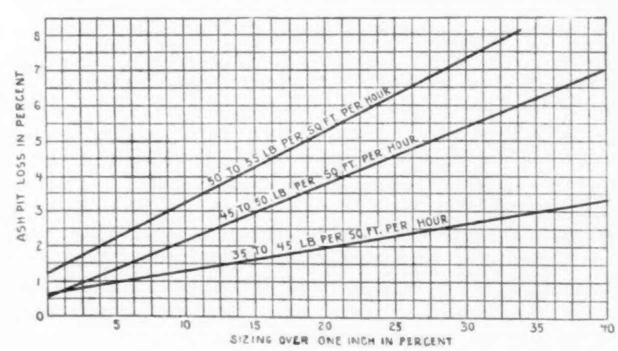


FIG. 4 VARIATION OF ASHPIT LOSS WITH RATE OF COMBUSTION

than 1 in.; but in the attempt to crush all the coal to $^3/_4$ in., the percentage of fine coal, that is, coal less than $^1/_4$ in. in size, is greatly increased. This condition is also objectionable.

The tendency toward higher ashpit losses as the coal is coarser is also proportional to the rate of fuel consumption. Referring to the curves shown in Fig. 4, with the same fuel sizing but burning at different rates the tendency is for the higher rate of fuel consumption to result in higher ashpit losses. For instance, coal with 10 per cent over 1 in. will give a loss of 1.3 per cent at a 35-lb. coal rate, while at a 50 lb. rate the loss will be more than double.

These curves will vary with the different types of stokers; being higher with natural-draft stokers than with forced-blast stokers, but the tendency is the same.

Burning coarse coal may introduce another loss, namely, that of excess air through the fuel bed. But with competent firing this loss can be controlled within limits by proper manipulation of the grate speed and air supply.

The CO_2 can be controlled with possibly a slight decrease in capacity so that the excess air is no more with coarse coal than with coal of the most favorable size when considered on the basis of actual combustible burned. The correct sizing therefore resolves itself into a minimum above 1 in. and a maximum from $^1/_2$ in. down.

The results of a test made on a crusher recently installed are

TABLE 1 CRUSHING TEST WITH SOUTHERN ILLINOIS LUMP COAL

	Lb.	Per Cent
Sizing over $1^1/_2$ in.	1.5	1.06
Sizing over $1^1/_8$ in.	2.0	1.40
Sizing over 1 in.	7.0	4.91
Sizing over $^3/_4$ in.	15.0	10.58
Sizing over $^1/_2$ in.	28.0	19.73
Sizing over $^3/_8$ in.	21.0	14.81
Sizing over $^1/_4$ in.	23.0	16.21
Sizing under $^1/_4$ in.	44.0	31.30
TOTAL	141.5	100.00

shown in Table 1. (F. C. Duennes in *Power Plant Engineering*, vol. 30, no. 23, Dec. 1, 1926, p. 1257, 2 figs., *ep*)

Utilization of Bituminous Coal in the Manufacture of Water Gas

CERTAIN economic and technical conditions govern the selection of the material from which water gas might be manufactured. Anthracite is the most suitable material from a technical point of view. Retort coke comes next. Both of these fuels are, however, now so high in price that attention is being directed more and more to bituminous coal. The author states briefly the history of the development of this process, which was long, slow, and expensive. Ultimately, however, ways have been found to produce water gas from bituminous coal in a reliable manner, and now the question is simply whether the cost factor is in favor of using it, which depends entirely on local conditions.

It is believed that one of the most important reasons for the present success of bituminous coal as generator fuel is due to the fact that the gas industry is now operating under a heating-value standard and the object is to extract from the coal the maximum amount of B.t.u. in the gas formed that can be economically enriched to give the desired heating value. This latter fact has permitted the use of the blow run, which in the author's opinion has been a most important factor in the economic development of the use of bituminous coal.

Of importance in insuring the success of the process were also the methods of controlling operating conditions, such as the air and steam meters, pyrometers, automatic control for the operating mechanism, installation of waste-heat boilers and the back run and down run to conserve the sensible heat in the off-going products.

One of the most troublesome features in work with bituminous coal was the formation of a central core of uncarbonized fuel which proved to be the cause of blowholes. The most successful method for preventing the formation of the unburned core of fuel and keeping the whole fire open and active was by mixing 30 to 50 per cent of coke or anthracite coal with the bituminous coal. Many plants are operating today on such coke and coal mixtures, but this means that two types of fuel must be handled, and the possible saving by the use of the cheaper fuel is reduced. There are bituminous coals which do not form such a core, but they are encountered only in a few places.

Satisfactory results have been obtained under proper conditions by what is known as the "pier" process. This process was based on the observation that the active zone in the generator fire when using bituminous coal extended from 18 to 24 in. from the walls and that the high temperatures developed next to the wall made this section of the fire equivalent to a retort and the coal was coked by the combined influence of the conducted and radiant heat. This observation explained how generators approximately 3 to 4 ft. in internal diameter could be operated with practically no loss in capacity, while generators of 8 or 9 ft. internal diameter had their capacities reduced approximately 50 per cent.

It was found that by removing the uncarbonized core of coal and replacing it with a refractory pier, there was then set up a second active zone surrounding the pier for 18 to 24 in., and if the pier was so proportioned that no portion of the fuel bed was more than 18 to 20 in. from a refractory surface, that the whole bed was active and that there was no formation of an inactive core, that blow holes were eliminated, and that the capacity of the generator was restored.

In other words, in operating with bituminous coal, the capacity of the generator was dependent upon the coking capacity of a retort 18 in. in depth and whose area was the periphery of the refractory linings against which combustion could take place, rather than depending upon the area of the grate surface. While this would appear to be a very simple step, yet successful results required a very considerable amount of experimental work in determining the proper size and construction of the piers.

It has been found that due to mechanical difficulties it is difficult to install piers in generators much smaller than 9 ft. in internal diameter and the same results can be obtained by building a cross-wall of refractory material in the generator. This gives the same effect of the additional hot surface for carbonization and is not subject to mechanical limitations of tipping.

The introduction of the pier or its equivalent cross-wall has successfully eliminated all the objections to the use of bituminous coal and has permitted the successful operation of the largest generators.

As mentioned before, one of the most important operating features of the operation for bituminous coal was the use of the blow run. This consists essentially in diverting a rich producer gas formed at the end of the blow into the holder by shutting off the carburetor blast and closing the stack valve from 10 to 17 sec. prior to the beginning of the run or the addition of steam. The blow run thus allows additional blasting time for the fuel bed and conserves the high heating value of gas at the end of the run where the heating value may rise to 135 to 150 B.t.u.

It is obvious that the use of the blow run considerably increases the capacity of the set, but since the blow-run gases are essentially a rich producer gas they contain considerable quantities of inerts and the amount of blow-run gas used must therefore be regulated, having regard to the result in the increase in specific gravity of the gas and the loss in heating value which must be made up by the use of additional oil.

However, in view of the increase in the heating value of the blue gas made with bituminous coal over that made with coal, with careful operation there need be no increase in the amount of oil used per 1000 ft. of gas oven with the blow run.

The author describes in some detail the Young-Whitwell back-run process and the Chrisman down-run process, as well as several other devices, such as the checkerless carburetor, etc. Methods of calculating the efficiency in the use of gas oils are discussed in the original article. (W. H. Fulweiler, Chemical Engr., The U.G.I. Contracting Co., Philadelphia, Pa. Paper before the International Conference on Bituminous Coal, Pittsburgh, Pa., Nov. 15–18, 1926, abstracted through the *Gas Age-Record*, vol. 58, no. 22, Nov. 27, 1926, pp. 759–762, 764 and 768, *pg*)

Recovery of Phenols from Steel-Plant Fuel Tars

RECENT estimates give the annual production of coal tar in the United States at about 550,000,000 gal., of which 350,000,000 gal. are burned as industrial fuel and the remainder distilled. The steel industry is the largest producer and consumer of coal tar in this country.

The author suggests that phenols be recovered from the coal-tar fuel burned in steel plants, and thinks that this could be accomplished easily and cheaply without seriously affecting the fuel value of the tar by distilling the raw tar to remove such oils as contain the main quantity of phenols, recovering the phenols from the oil, and cutting back the pitch from the distillation with the extracted oil. The resultant mixture of pitch and oil would be a dehydrated acid-free tar for fuel purposes which would still contain 95 per cent of the total available heat units in the raw tar, while phenol and cresols would be produced in adequate quantities for the domestic market. The details of the operation are stated in the article.

An estimate of the cost of operation for a steel-works coke plant producing 70,000 gal. of raw tar per day is given in the original article. (Robt. M. Crawford, Chemical Engineer, Pittsburgh, Pa., in a paper before the International Conference on Bituminous Coal, Pittsburgh, Pa., Nov. 15–18, 1926. Abstracted through *Gas Age-Record*, vol. 58, no. 22, Nov. 27, 1926, pp. 763–764, *p*)

INTERNAL-COMBUSTION ENGINEERING

A New 600-B.Hp. Heavy-Oil Engine

DESCRIPTION of a British (Belliss-Morcom, Ltd., Birmingham) type in which no radical changes have been incorporated but many refinements in design have been made. The distance between the centers of the cylinders was reduced without sacrificing necessary

bearing lengths. It amounts to about 1.7 times the diameter of the cylinder. At the flywheel end of the engine it was found possible so to increase the length of the bearings on either side of the skew-gear wheel on the crankshaft that the usual outboard bearing is dispensed with and a correspondingly shorter overall engine length obtained.

A one-piece crankshaft is employed with webs slotted from the solid forging. The connecting rods are also steel forgings and are furnished with marine-type top and bottom ends having white-metal-lined steel bearing shells. The crankshaft and connecting rods are drilled for forced lubrication, the oil being supplied under a pressure of about 10 to 15 lb. per sq. in. from a common rail fixed inside the crank chamber. The piston is made with a removable head which is oil cooled on the labyrinth principle, the cooling oil being supplied to and taken from the piston through swinging links (Fig. 5). Another common rail which runs along the other side of the crankcase supplies the piston cooling oil at a pressure of about 25 lb. per sq. in. All the oil outlets are fitted with separate tundishes or funnels so that the attendant can note the temperature of the cooling oil discharged from each piston. The details of cylinder covers, valves, fuel pump, injection-air compressor, lubricating pump, and filter are given in the original article. The exhaust manifold is water-cooled and is arranged to take the cooling water discharged from all parts of the engine. A test made with a multiple compound pyrometer attachment under full-load rating has shown the average exhaust-gas temperature at the exit from the cylinders to be about 737 deg. fahr. with a plus or minus difference between the cylinders of not more than, say, 40 deg. (*The Engineer*, vol. 142, no. 3696, Nov. 12, 1926, pp. 532–533, 4 figs., *d*)

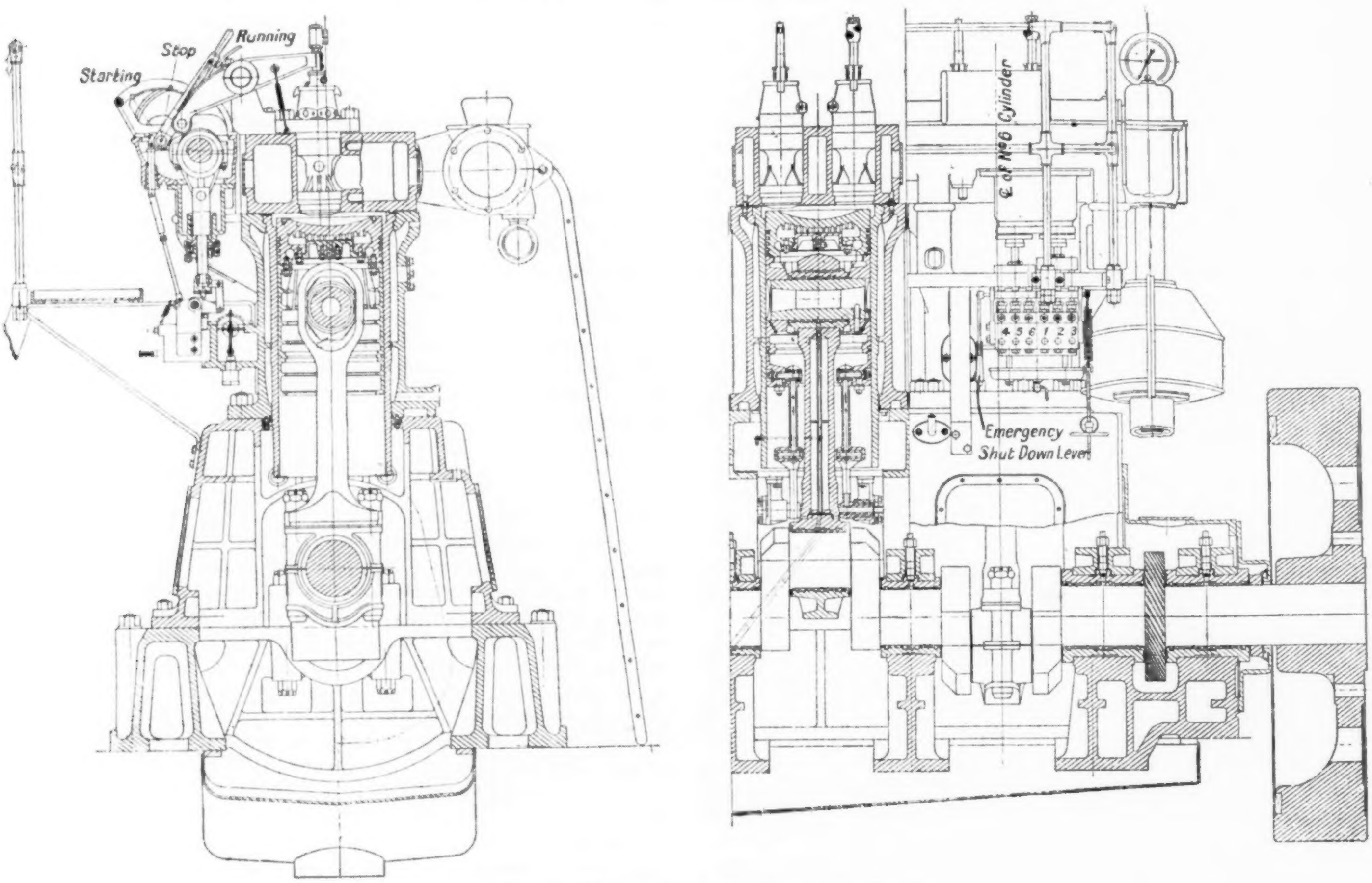


FIG. 5 BELLISS-MORCOM 600-B.HP. HEAVY-OIL ENGINE

Tests on Preheating Heavy Fuels for Diesel Engines

THE Fulton Iron Works Co. has made several tests on the preparation and burning of heavy fuel oils in Diesel engines, one being just completed on one of their standard engines. The engine with which this test was made was a five-cylinder, air-injection, single-acting, four-stroke cycle, vertical en-bloc type engine with cylinders 23 in. by 26 in. rated at 1000 b.hp. at 200 r.p.m. The same fuel pump and fuel-injection valves were used for burning the heavy fuels as are regularly used for burning the lighter and more expensive ones.

The results of running this engine with Mexican and bunker oils have proved to be satisfactory, notwithstanding the fact that some very heavy oils were used. There was no trouble whatsoever in keeping a clean exhaust from no load to 20 per cent overload, the engine taking the heavy fuel oil as readily as the lighter. The consumption of the heavy fuel oil as compared with the lighter was in proportion to their heat values.

A chart is given in the original article showing diagrammatically the path of the water and oil in the preheating system. The heating unit has a coil placed in the exhaust manifold. By having this coil liberally proportioned it becomes possible to secure abundant hot water to raise the temperature of the oil sufficiently to reduce its viscosity to a point where it can be readily filtered and passed through the fuel pump. After leaving the heating unit coil the hot water divides into four branches, one inside of the fuel supply line, one in the oil filter, one in the air dome, and one in the fuel pump. An additional heating coil may have to be placed in cooler climates in the overhead heavy-fuel-oil supply tank. In tropical climates the heavy fuel oil will flow from the overhead tank to the engine without heating, provided very large fuel pipes are used. Assuming this latter condition, a pipe through which hot water is circulating is placed inside of the fuel supply pipe approximately 8 or 10 ft. ahead of the filter. Its function is preheating the fuel oil sufficiently for it to flow into the filters. After the heavy fuel oil has entered the filter it has to be heated considerably in order that it may pass through the filtering elements. Some other minor changes have been made. For example, instead of locating the oil filter on the side wall it has been mounted on the side of the engine close to the fuel pump which has the advantage that no noticeable drop in temperature is caused when the oil is flowing from the filter through the air dome to the oil pump.

The air dome has a double purpose. First, it acts as an air cushion, taking up all pulsations which occur in the suction line of the fuel pump due to the suction of the plungers. If it were not for this air dome these pulsations would be carried through the whole fuel system to the overhead fuel supply tank and it would be necessary to provide an open auxiliary fuel tank as close as possible to the fuel pump. However, with the air-dome system, an open fuel-supply tank close to the fuel pump can be avoided, and the main overhead fuel-supply tank can be placed at the most convenient part of the building regardless of the distance from the engine. Viscous oils are more likely to contain water and mineral impurities in suspension than the lighter oils, and in certain cases preheating to reduce the viscosity to the required amount will cause the oil to bubble and emit vapors. These vapors result in irregular fuel-pump action. However, with the air-dome system and the heating coil therein, any such vapors have an opportunity to escape into the dome, where they may be drawn off by a valve.

In burning the heavy oils it is necessary to start the engine. with a lighter fuel oil. After the engine has been operating for approximately half an hour it can be switched to the heavy oil by simply turning a valve. Before stopping the engine after it has been running on heavy fuel, it is desirable to switch back and run on the lighter oil for about half an hour. The purpose of this and the control of temperature of the oil are explained in the original article. (*Oil Engine Power*, vol. 4, no. 12, Dec., 1926, pp. 756–758, 3 figs., *de*)

MACHINE PARTS (See Testing and Measurements: Researches on Piston Rings)

MARINE ENGINEERING (See Steam Engineering: Combination Marine Steam Power Plants)

METALLURGY (See also Engineering Materials: Copper-Beryllium Alloys)

Steel Direct from Ore

An announcement has been made that at the Lorain, Ohio, works of the National Tube Co., a subsidiary of the U. S. Steel Corporation, a plant is under construction in which iron will be produced from the ore without the use of a blast furnace. The Hornsey process will be employed. For further information about this process, see Mechanical Engineering, vol. 46, no. 8, Aug., 1924, p. 491. Briefly the process calls for the crushing of the ores, after which they are charged with coal into a rotary kiln heated to a definite temperature. The fine material then passes into a second kiln heated to a higher temperature and thence to a third kiln where it is subjected to sudden chilling. The material is then passed over magnetic separating rolls. The result is iron in the granular form, which can be charged into open-hearth or electric furnaces. It is understood that some of the details of handling this material for charging into the furnaces are yet to be worked out. (*Forging, Stamping and Heat Treating*, vol. 12, no. 11, Nov., 1926, p. 434, and editorial in *Iron Age*, vol. 118, no. 19, Nov. 4, 1926, p. 1924, *dg*)

MOTOR-CAR ENGINEERING

The British Daimler and Wolseley Cars

At the 1926 Olympia motor-car show, the Daimler Company showed a car equipped with a 12-cylinder sleeve-valve engine. This engine, called "double-six," has two sets of six cylinders arranged in V and disposed obliquely on either side of the vertical center line, all twelve working on a common crankshaft. The connecting rods of one side of the engine have forked big ends in order that the opposite cylinders may be situated in the same plane. The cylinders are equipped with steel sleeves operated by two eccentric shafts, each mounted on four bearings and driven by separate silent chains from the rear end of the crankshaft. An unusual feature of the engine is the method employed in heating the mixture in the induction pipes, which is done by means of an internal water pipe through which the jacket water circulates. The exhaust pipes are located between the two banks of cylinders under the cowl, and the fan delivers air into the channel thus formed.

The brake system of the Daimler car is of special interest. A hand brake operates on a drum behind the gear box, but the foot brake acts on all four road wheels and is power-assisted on the Dewandre system. The mechanical force on the brakes is applied by means of a piston operating in a cylinder that communicates with the induction pipe through a valve connected to the brake pedal. When the driver depresses the pedal the valve is opened and the suction in the induction pipe creates a partial vacuum in the cylinder, causing the piston to travel and augment the force applied by the driver to the pedal. The connections between the piston and the brake mechanism on the one hand and between the pedal and the valve on the other are so arranged that the driver's foot is the fulcrum of a system of levers through which the piston acts, and the consequence is that not only is the auxiliary mechanism unable to operate independently of the driver, but his force is under direct control. This is shown in further detail in an illustration in the original article.

The six-cylinder engine of the Wolseley car is capable of revolving up to 4000 r.p.m. without any vibration. This result is largely brought about by the use of a massive seven-bearing crankshaft accurately balanced both statically and dynamically and supported in a rigid and deep crankcase. The diameters of the main bearings of the crankshaft are, however, 70 per cent of the cylinder bore, while the flywheel bearing is $2^1/_2$ in. in diameter. (*The Engineer*, vol. 142, no. 3693, Oct. 22, 1926, pp. 439–442, illustrated, *d*)

Increased Compression Ratio in Motor-Car Engines

The author believes that if anti-detonating fuels should find a wide market and their distribution become general it is not inconceivable that engine builders would design their engines to operate at higher compressions. With fuels of the characteristics of ethyl gasoline, for instance, a compression ratio of seven to one would be quite practicable. The author gives two ways of calculating the increased efficiency. By one method he shows that if the compression ratio is increased from 4 5 to 7, the thermal efficiency is increased 19 per cent; by the other (by figuring the amount of mechanical energy developed per charge with each ratio) he finds that there would be an increase of thermal efficiency of 26 per cent. He also figures out that the change in the compression ratio from 4.5 to 7 would produce an increase in brake horsepower of from 20 to 25 per cent.

He also considers another method of increasing the expansion ratio, and that is by continuing the expansion beyond the volume which the charge occupied when at atmospheric pressure previous to compression. He makes a reference to the Atkinson engine with a compound crank mechanism whereby the piston would perform alternately two long and two short strokes, the expansion and exhaust strokes being long and the inlet and compression strokes short. He also describes briefly a recently invented (in England) double-piston engine with compression and expansion strokes twice as long as the inlet and compression strokes. As a matter of fact, the same purpose can be accomplished readily by a change in the valve timing, as the author explains in considerable detail. He also shows, however, that little practical gain can be derived from any of the processes of what might be called super-expansion. It may have, however, some advantages in aircraft engines, as well as in other lines of application where the average power factor is high, such as, traction and marine work. (T. M. Heldt in *Automotive Industries*, vol. 55, no. 21, Nov. 18, 1926, pp. 844–847, 5 figs., *t*)

A Large-Ratio Variable Gear

Description of gears developed in England with which ratios as high as 3000 to 1 can be supplied. The gears represent a combination of worm and special spur gear. The gears may be provided with an attachment which gives a variable speed from full speed to zero on the slow-speed shaft at constant torque. Thus, by means of this gear a motor speed of 1800 r.p.m. can be reduced to 6 r.p.m. with a variable-speed attachment, giving on the slow

shaft any speed from 0 to 6 r.p.m. As regards the torque on the slow-speed shaft, it is stated that 1 hp. at one-sixth of a revolution per minute represents a pull of over 14 tons at 12 in. radius. No details of construction beyond one illustration are given. (*Mechanical World*, vol. 80, no. 2079, Nov. 5, 1926, p. 336, 1 fig., *d*)

RAILROAD ENGINEERING

A 2500-B.Hp. Turbine Locomotive

A new 2500-b.hp. steam-turbine express locomotive, was completed in the locomotive works of J. A. Maffei of Munich, Germany, a short while ago. The steam turbine, located at the front of the boiler, drives through gears a shaft carrying a crank disk and crankpin at each end which drive the wheels in the usual manner, the gear reduction being 1:24. The ahead and astern turbines are arranged in a single casing. A small turbine for producing the vacuum in the smokebox is situated in the center of the smokebox door. The boiler pressure is 22 atmos. The exhaust steam of the turbine is condensed in two surface condensers arranged at the sides of the boiler, and the heated cooling water is recooled in a special sprinkling cooler situated on the tender. The maximum speed of the locomotive is 120 km. an hour. (*Engineering Progress*, vol. 7, no. 10, Oct., 1926, p. 283, *d*)

Passenger Cars with Anti-Friction Bearings

As a result of tests conducted over a period of two years on roller bearings in passenger cars, the Chicago, Milwaukee & St. Paul recently decided to make an extensive installation of roller-bearing-equipped passenger trains. Sixty-four new Pullman cars and 63 cars owned by the St. Paul were ordered fitted with roller bearings. The experience of the St. Paul in testing roller bearings was outlined recently by L. K. Sillcox (Mem. A.S.M.E.), Gen. Supt. of Motive Power, in a paper read at the Chicago, Milwaukee & St. Paul Annual Car Department Staff Meeting (Milwaukee, Sept. 20–22, 1926).

Among the advantages which test experience on the St. Paul indicates may be expected of roller bearings as applied to passenger-car equipment, are reduced train resistance, practical elimination of rough handling in starting long trains, easier riding equipment, less chance of hot boxes, ample warning when defects develop, fewer slid flat wheels, and a saving in lubricants. Another practical consideration is the possible elimination of different engine ratings for summer and winter where air temperatures have a wide variation.

While roller bearings have been discussed and considered for steam-railway service during a period of almost 25 years, the missing quality has always been that of durability, and designers of such bearings in their efforts to produce something suitable apparently erred on the side of giving the mechanics of the subject too much attention. They seemed to be interested chiefly in obtaining large contact areas, and in their endeavor along these lines unfortunately neglected many other essentials which were necessary in the development of this heavy type of bearing.

Eventually it was realized that it was not sufficient to state simply that a bearing dealt with so many pounds load at a certain speed. The fatigue-resisting properties and ability of the bearing to absorb and direct elements of side thrust under very difficult conditions of load and speed, needed consideration as well. Where the loads were high, but the speed low, the problem could always be solved by means of a ball-type bearing; but such bearings would have to be of dimensions quite impracticable in many cases, and necessitated redesign of truck frames and associated parts in order to accommodate the new construction. This fact, together with the higher cost of the bearing itself, presented a problem which has until recently appeared insurmountable from a financial standpoint.

Tests on the St. Paul have indicated the basis on which selection of roller bearings should be made. This is as follows: Minimum friction; ability to deal with both thrust and radial loads; ability to deal with thrust load in one direction; ability to operate successfully for at least 1000 miles after becoming initially defective, in order to allow a car to be brought to a terminal; ability to operate a minimum of 600,000 miles without failure of parts, wreck damage excepted; the unit should be self-contained, with a minimum number of loose parts, and should be non-adjustable; the unit should be capable of quick inspection; the unit should have the feature of self-alignment.

The question of lubrication was carefully considered and grease selected as the proper lubricant. The advantages of installation of roller bearings are discussed in detail. Tests on the St. Paul indicate that with steel sleepers the starting resistance on cars equipped with plain bearings may be as high as 55.6 lb. per ton; for steel coaches, 54.4 lb. per ton. Under the same conditions at the same time the resistance for steel coaches fitted with roller bearings was 7.59 lb. per ton. Under the circumstances it is possible to require in starting the Pioneer Limited's 15 cars an effort from the locomotive of 67,200 lb. for equipment fitted with plain bearings as against 9120 lb. required under these circumstances for equipment fitted with roller bearings, all in the ratio of approximately seven to one. The effect of roller bearings and brake action was also studied. (*Railway Age*, vol. 81 no. 18, Oct. 30, 1926, pp. 835–838, illustrated, *pe*. Compare also *Railway Mechanical Engineer*, vol. 100, no. 11, Nov., 1926, pp. 667–670, illustrated)

SPECIAL MACHINERY

An Electrically Operated Forging Press

Description of a press built by the Kalk Machine Works in Germany. The type described in the article is a one-sided hammer press with overhanging frame rated at 600 tons pressure. It is claimed that as the press works steadily without causing shocks, neither powerful foundations nor special anvil blocks are needed, forging pressure being taken up by the frame which is a steel casting.

The monkey is driven from an electric motor through a double spur-wheel gear, a crankshaft, and a double-arm rocking lever of cast steel, the front end of which is linked to the monkey. The center of rotation of the lever is situated in the middle and can be adjusted accurately in respect to the working piece by means of a small independent-control motor.

Pressing and forging in accordance with predetermined measures are facilitated by an indicator actuated by the center of rotation of the rocking lever. The indicator travels along a scale showing the clear distances between the anvil surface and the lower surface of the monkey for each lowest position of the monkey.

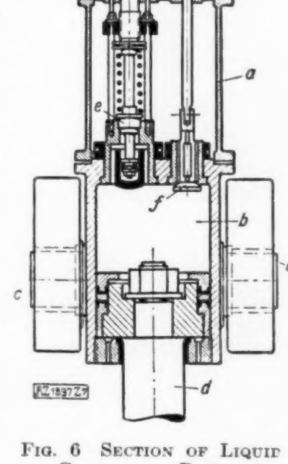


Fig. 6 Section of Liquid Cushioning Device
(*a*, filling cylinder; *b*, pressure cylinder; *c*, journals; *d*, wing rod and piston; *e*, pressure safety valve; *f*, suction valve.)

The crank gear causes definitely limited individual strokes to be imparted to the monkey. Contrary to the types of forging presses hitherto known, it is possible with this new design of forging press to forge work pieces accurately to measure without being forced to have recourse to patterns for measuring or wasting time on measuring over and over again with a foot rule during the forging process. This feature is of particular significance when finishing up bars of polygonal or round section, as accurately and definitely determined strokes from the same altitude are applied continuously, once the press monkey has been set correctly. Slight fluctuations in the temperature of the work pieces are of no consequence. A further important advantage of the new forging press as compared with forging hammers consists in the fact that exactly the same pressure can be brought to bear upon the work piece whether it be a particularly tall one or one possessing but little height. The forging presses are driven by a 220- or 440-volt d.c. work-governed motor [manufactured by the A.E.G. (General Electric Co.) of Berlin], employing a double spur-wheel gear.

Fig. 6 is an illustration showing a section of the liquid cushioning device embodied in every forging press with electric drive in order

to protect it against damage through overstressing. This device is placed between the crankshaft and the longer rear end of the rocking lever, and serves to prevent the machine from being overloaded in the event of the forging being too cold. For this purpose the opposite end of the crankshaft wing rod *d* is designed as a leakproof piston working in pressure cylinder *b*. The latter, together with the filling cylinder *a* situated above it, is supported by two journals *c* in the forked rear end of pressure lever *g* so as to permit of oscillating. A pressure safety valve and a suction valve *f* are provided between the two in the bottom of the cylinder. The safety valve *e* is adjusted for the maximum forging pressure permissible with any given type of press. As soon as this maximum pressure is exceeded, the safety valve begins to blow off, while the piston of the wing rod which until this moment formed a rigid crosshead with the pressure cylinder, now begins to be pushed into the pressure cylinder, simultaneously forcing the liquid over into the filling cylinder, without, however, at the same time causing the monkey to move down still further. The liquid now contained in the filling cylinder (oil for preference) is sucked back automatically by the next downward stroke of the crank. The press is therefore ready again immediately for continuing with work. In order to warrant reliable working of the suction process, a stripper cam with a helical exterior surface is provided on the frame underneath the pressure lever. This cam is controlled automatically by the fulcrum gudgeon of the lever which is adjustable vertically. This arrangement insures sucking taking place with complete certainty at any position of the monkey. (A. Friederici, Düsseldorf, in *Engineering Progress*, vol. 7, no. 11, Nov., 1926, pp. 309–311, 4 figs., *d*)

SPECIAL PROCESSES (See also Fuels and Firing: Manufacture of Water Gas from Bituminous Coal; Recovery of Phenols from Steel-Plant Fuel Tars—Metallurgy: Steel Direct from Ore)

The Liebreich Process of Chromium Plating

This process was recently installed at the works of the Metropolitan-Vickers Electrical Co., England, and is reported to produce satisfactory results. Liebreich uses an electrolyte consisting of a colloidal solution of oxides of chromium of valency 2–3, obtained either by electrolysis or by heating crystalline chromic acid or potassium bichromate to the melting point.

The electrolytic method of preparing the bath is based on the following: In the electrolysis of chromic acid the current-voltage curve shows three abrupt increases, separating stages in which the following actions occur:

1 Reduction without evolution of hydrogen and with no deposition of metal, except that a bright golden liquid film is visible on the cathode when it is removed from the bath;

2 Formation of a colloidal coating of red to brown chromium chromate in which the metal is substantially trivalent;

3 Formation of the required chromous chromite of dark color, with very little hydrogen;

4 Deposition of metal powder and evolution of hydrogen at a current density of 60 amperes per square decimeter.

The deposit of chromous chromite from stage 3 is dissolved in water to form a colloidal solution to which may be added trivalent compounds of chromium sulphate and also weak acids such as boracic acid. Chromic acid and chromates must be absent or only present in trifling proportions. Such a solution gives a bright, coherent deposit of chromium at voltages less than that corresponding to stage 4 of the decomposition of chromic acid. (*Brass World*, vol. 22, no. 11, Nov., 1926, p. 342, *d*)

A New Plating Process

A method has been discovered for plating in Germany, so far applied chiefly to precious metals. In this the metal is deposited on articles by means of electricity in a high-vacuum container without additional acids. The objects are placed in a high-vacuum container substantially free from air and containing electrodes of precious metals. When the vacuum has reached the proper stage, current is applied by means of which tiny particles of metal are loosened and drawn along. Their speed is so great that they impinge with enormous force against everything standing in their way. The deposit is said to adhere firmly and is able to withstand mechanical handling, such as pressing and rolling. Even materials such as textiles, laces, etc., may be subjected to this process. The peculiar characteristic of the process is that dull objects stay dull after metalizing, while polished objects remain polished. (*Brass World*, vol. 21, no. 11, Nov., 1926, p. 344, *g*)

STEAM ENGINEERING

Combination Marine Steam Power Plants

Attention is being paid in Germany to a method of increasing the economy of marine steam engines which depends on the addition of low-pressure turbines to reciprocating engines. This combination system is not in itself new, for even before the war triple-screw vessels had been built in which the exhaust steam from the port and starboard reciprocating engines was used to drive a low-pressure turbine placed in the center line of the ship. The novelty of the new system, which has been devised by Dr. Ing. Wach, director of the shipyard of Messrs. J. C. Tecklenborg, at Bremerhaven-Geestemünde, and by Professor Bauer, of Hamburg, lies in the fact that the exhaust steam of the reciprocating engine is used in a small high-speed turbine which by a double-reduction gear works upon the same line of shafting as is driven by the reciprocating engine.

The first plant of this type was installed in the German trawler *Sirius*, and has been under close observation for some months. In this vessel the boiler pressure is about 220 lb. per sq. in., and superheating is employed. The reciprocating engine develops 650–700 hp. at 110 r.p.m. Double-reduction gearing and a hydraulic coupling filled with pressure oil have been arranged between the turbine and the propeller shaft. The large wheel of the gear is fixed by a flange connection of the usual type on a hollow shaft drawn over the propeller shaft between the screw and the reciprocating engine, at some distance from the latter. This hollow shaft runs in bearings of its own, and hence the unavoidable lowering of the crankshaft of the reciprocating engine, caused by wear of the main bearings, does not affect the gearing. The hydraulic coupling is placed between the pinion that drives the large wheel and the tooth wheel of the second part of the reduction gearing. Thus when the turbine is disengaged only the large wheel and one pinion run with the reciprocating engine, and if desired these parts can quickly be disengaged by dismantling the flange connection. The double-reduction gearing gives a large ratio of reduction, and enables the turbine to be run at high speed, with the advantages that it is economical in operation and can be made of small size and weight.

Maneuvering of the machinery would be difficult, on account of the high speed of the turbine, were the turbine rigidly connected to the reciprocating engine, but this difficulty is avoided by the hydraulic coupling, which enables the turbine to be engaged or disengaged while the reciprocating engine is working. For disengagement the oil pressure in the hydraulic coupling is relieved, with the result that the exhaust steam from the reciprocating engine is cut off from the turbine and made to flow directly to the condenser. Then the oil is pumped out, so that the coupling becomes looser and looser until the turbine, still rotating rapidly owing to its momentum, is entirely free from the reciprocating engine, which may then be reversed in the usual way. The whole operation takes only a few seconds. For engaging the turbine the process is reversed; the coupling is brought into action gradually and then steam is admitted, racing of the turbine being thus prevented.

Trials on the test bed at Messrs. Tecklenborg's works showed that the addition of the low-pressure turbine gave an increase of power up to 34 per cent. In trials of the plant after it had been built into the trawler the maneuvering qualities proved excellent, and there was found to be a saving of fuel of from 25 to 30 per cent in comparison with reciprocating marine engines of similar power. Results obtained during the first voyage indicated that if only the reciprocating engine had been working the fuel consumption would have been 29 per cent greater for the same speed.

The new system permits use to be made of high vacuum in installations of low power, and enables old installations to be

increased in power and efficiency without very extensive changes. In carrying out a conversion the reciprocating engine remains entirely unaltered, and room for the turbine may be found by replacing the normal thrust bearing with a shorter one of the modern single-collar type. In such a case the increase in the power of the machinery may amount to 25 to 30 per cent without any change in the boiler plant, though if it is increase in power that is desired the condensing plant must be increased in order that it may give a higher vacuum. If, however, it is desired only to reduce the fuel consumption, the old condensing plant will usually be sufficient, as on account of the smaller consumption of steam the higher vacuum will result automatically. Generally, however, in view of the tendency toward higher speeds exhibited in ships of recent construction, it seems probable that increased power will be the object sought in adding low-pressure turbines to reciprocating engines.

The interest of the German shipping industry in the new system is shown by the fact that the North German Lloyd have contracted with Messrs. Tecklenborg for the addition of a low-pressure turbine to the 4000-hp. reciprocating engine of their steamer *Elberfeld*, of 9250 tons deadweight. The power of this vessel will thus be increased to over 5000 i.hp. The Hansa Steamship Company have also ordered a low-pressure turbine for one of their steamers, of 11,400 tons deadweight, the engine of which is rather larger than that of the Elberfeld. (Correspondence from an engineering correspondent in Hamburg. *The Times Trade and Engineering Supplement*, vol. 19, no. 433, Oct. 23, 1926, p. 147, *dg*)

TESTING AND MEASUREMENTS

Researches on Piston Rings

WITH a view to improving the piston ring the amount of radial pressure exerted by the ring on the cylinder wall was ascertained, which was done first by mechanical methods and next by a piezoelectric device.

Fig. 7 represents the apparatus for measuring the piston ring. In place of the cut in the cylinder wall *QR*, a piezoelectric crystal *C* is introduced, and the radial pressure exerted on the crystal by the corresponding part of the ring is determined by the amount of electric charge which is to be proportional to the change of the pressure on the crystal. *A* is a thick steel plate, having its inner surface well machined and finished with a grinder to a diameter identical with the inner diameter of the cylinder in which the ring is to be placed for use. *B* is a piece taken from the cut *QR* in the steel plate. At *C* there are two quartz crystals, each being 3.5 cm. in diameter and 1.2 cm. in thickness; a thin copper plate is inserted between them so as to lead the electric charge produced on their surfaces; at *D* are thin steel disks. *B*, *C*, and *D* are tightly held by four bolts *E* to the steel plate *A* so that the crystals are initially compressed under a certain pressure. Thus the radial pressure on the segment *QR* exerted by the ring is completely borne by the crystals. The surface of the block *B* exactly coincides with the circumference of the inner surface of *A* and measures $2a = 127.08$ mm. ± 0.008 mm. At *F* are hemp or copper strips to adjust the position of the ring, and one of them is also used to set free the ring from the block *B* so as to unload the crystals, and the change of the pressure on the crystals is measured by the amount of electric charge. Another figure in the original article shows the general arrangement, which includes the testing apparatus shown in Fig. 7, a Shimiz sensitive electroscope, and a group of storage batteries. The silvered quartz fiber of the electroscope is charged with 100–150 volts, and one of the poles is earthed and the other connected with the copper plate between the quartz crystals. To avoid electromagnetic induction the apparatus and lead wires are shielded in iron boxes and pipes.

Method of Making Observations. To determine the pressure distribution, the outer surface of the ring is oiled and inserted in the apparatus above explained. The deviation of the ring from the normal central position to either side due to the friction between the ring and the cylinder wall is adjusted by pulling the hemp strips. Next, the zero point of the needle of the electroscope is fixed, the residual charge of the quartz being earthed, and then the ring is separated from the piece *B* and the deflection of the needle read. It does not matter how the pressure is taken off the quartz crystals, whether suddenly or slowly, the results are always independent of the way it is done. If we know the sensibility of the electroscope, which can be calibrated by loading or unloading a known weight on or off the quartz crystals, the amount of the total force *F* exerted by a small part of the ring corresponding to the segment may be obtained. It has been confirmed by a series of careful examinations that such a simple method as using hemp strips is quite satisfactory for adjusting the deviation of the ring and for fitting it perfectly to the inner surface of the cylinder.

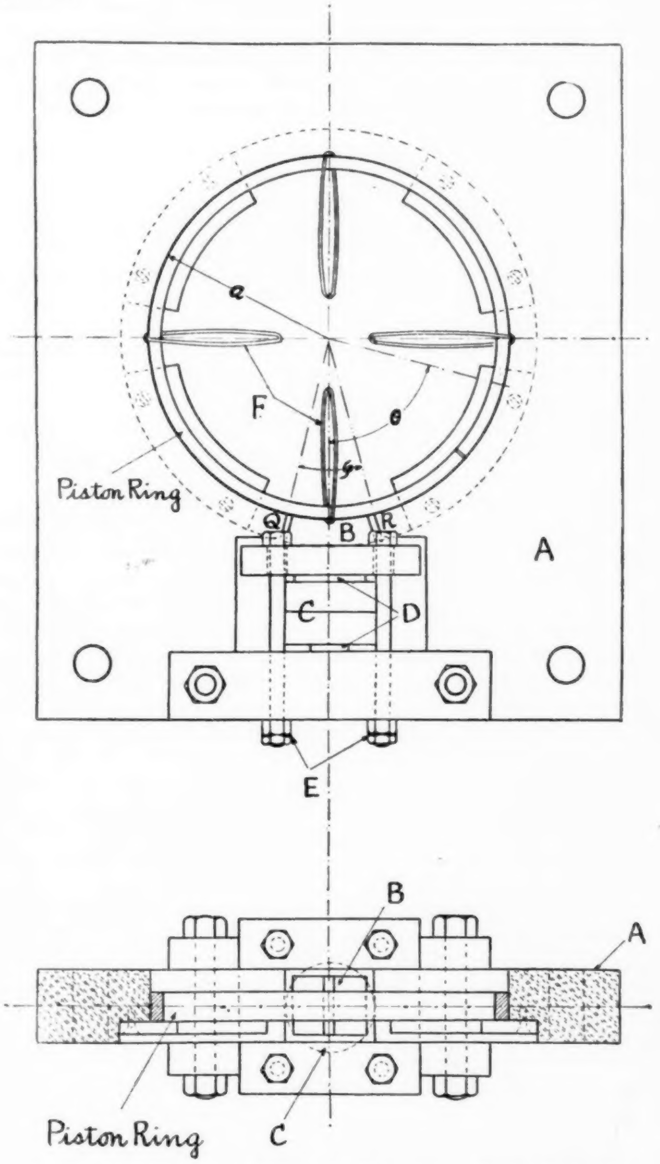


FIG. 7 PIEZOELECTRIC METHOD OF MEASURING PISTON PRESSURE ON THE CYLINDER WALL
(a = 63.54 mm.; φ = 28 deg.)

Letting a and b be the inner radius of the cylinder and the height of the ring, respectively, the following relation can then be obtained, assuming the intensity of radial pressure $p(\theta)$ on the segment $a\varphi$ is constant:

$$F = 2ba\int_0^{\frac{\varphi}{2}} p(\theta)\cos\theta\, d\theta = 2\,bap\sin\frac{\varphi}{2},\text{ or } p = \frac{F}{2\,ba\sin\frac{\varphi}{2}}$$

The intensity of pressure along the circumference of the ring is then to be calculated from the observed value of *F*.

Among other things, the effect of the annealing temperature of the ring on the pressure distribution was measured. It was found that the main pressure gradually decreases with the rise of the annealing temperature, rather rapidly beyond 300 deg.

cent. and drops down to half the pressure of the virgin ring at about 500 deg. cent. Moreover the configuration of the pressure distribution is not much affected by the annealing below 400 deg. cent. The effect of annealing on the main pressure is great for one or two hours, after which the time effect becomes weak. The relation between the gastightness and the pressure of the ring on the wall is next examined. An experiment has shown that the frictional resistance of rings amounts to about 60 per cent of the total resistance.

In the Japanese part of the article (the preceding was taken from the English part) a ring is described which exercises a nearly uniform pressure on the cylinder wall. (Keikiti Ebihara in a paper before the Society of Mechanical Engineers (Japan); *Journal of the Society of Mechanical Engineers, Tokyo*, vol. 29, no. 113, Sept., 1926, English part pp. 533–560, Japanese part 561–564, *ed*)

Velocity Measurements with the Universal Measuring Camera

The Universal measuring camera is one of the various photographic instruments for measuring initial velocities developed primarily for use in ballistics but applicable to other purposes. In contradistinction to other apparatus, the Universal measuring camera works with films, which is of great importance for an instrument to be used in the field because of safety of transportation, as glass plates may be broken and the results of tests destroyed thereby. It is true that plate distortion may occur when films are used. Glass plates, however, are not quite free from this either; besides, plate distortion plays a very unimportant part in comparison with other errors of measurement, if care is taken in the development of negatives.

One of the peculiarities of this camera is that by exposure one obtains not a sharp single impression of the moving projectile but instead an oblique streak across the film. This at first appears to be a deficiency in the method, but actually it is an advantage. Instruments that furnish sharp outlines of the projectile require at least two exposures at different points of its trajectory. Because of this, in order to measure the initial velocity it is necessary to resort by single exposures to two measurements of the negative; i.e., determination of the two points at which the impression of the projectile was taken. Only after computation of these can one determine the distance between these two points. As the time that intervenes between the two exposures is measured, the velocity of the projectile can be computed. This work is done automatically by the Universal measuring camera, since it photographs the time and gives other data from which the initial velocity can be computed.

The theory of measurement of the initial velocity by this camera is presented in detail in the article and the camera is described. Results of measurements made for three years on European proving grounds are given and are compared with those obtained by the Boulengé apparatus. The sources of error are enumerated and considered. By combination of all the above-discussed sources of error, the accuracy of photographic measurement of velocities with the Universal measuring camera varies within the following limits:

Computation of the measured distance:	$\pm$ 0.1 to 0.2 per cent
Computation of the time of passage:	$\pm$ 0.2 to 0.4 per cent

from which there results a computation of the velocities accurate to within 0.3 to 0.6 per cent. This has been confirmed in actual practice by comparison of measurements.

The probable deviation of the measured values from true values is about $\pm$ 0.4 per cent, but the precision obtained is fully adequate for the purposes required. (Article by Dr. of Engrg. Hans Rumpff—source not given—translated by Col. Geo. Ruhlen, U.S.A. Retired, and published in the *Coast Artillery Journal*, vol. 65, no. 5, Nov., 1926, pp. 429–455, 6 figs., *dt*)

THERMODYNAMICS

Contribution to the Theory of Heat Transfer from Liquids or Gases to Solid Walls

The purpose of the present article is to extend the existing theories and, in particular, to determine the consideration that should be given to the frictional heat due to turbulence. Reference is made to previous publications by Prandtl, von Kármán, Latzko, and Pohlhausen. The article is of a mathematical character and not suitable for abstracting.

The author starts with von Kármán's differential equation for the thickness of the limit layer. He shows that the heat transfer due to cell friction, for which he gives a mathematical expression, is materially affected when there are present a high velocity of flow and a small temperature difference between the wall and the gas. He discusses next the influence of the laminar end layer, which he defines as the layer located between the wall and the turbulent layer. Its thickness is determined by the requirement that at the limit layer the laminar-layer friction must coincide with the turbulent friction. He comes to the conclusion that in gas flow the laminar-layer transmission to the wall affects the heat transfer only to an insignificant extent, but in the case of liquid flow it has a material influence in the direction of reducing the transfer of heat. (Prof. A. Stodola, Zurich, in *Schweizerische Bauzeitung*, vol. 77, no. 18, Oct. 30, 1926, pp. 243–244, *mt*)

WELDING

Tests in Connection with Gas and Metal Arc Welding as Applied to Aircraft Construction

At the request of the Bureau of Aeronautics of the Navy Department, the Norfolk Navy Yard conducted a series of tests in order to determine certain facts in connection with the use of gas and metal arc welding as applied to aircraft construction. The materials tested were carbon sheet steel of various gages, S.A.E. 1025 with carbon content 0.20 to 0.30 per cent, chrome-vanadium sheet steel of various gages, S.A.E. 6130, nickel-steel tubing of various diameters and gages, S.A.E. 2330, and chrome-molybdenum tubing of various diameters and gaging, and Army Air Service specification No. 10231-A with carbon content 0.25 to 0.35 per cent, chromium 0.80 to 1.10 per cent, and molybdenum 0.15 to 0.25 (minimum) per cent.

From the tests conducted certain conclusions have been derived, of which the following may be mentioned. The flywheel effect of gas and metal arc welding decreases the ultimate tensile strength of unannealed material, the percentage of reduction being approximately the same for both methods of welding. It is believed that an allowance of 20 per cent reduction in the ultimate tensile strength of unannealed welded tubing for sheet would take care of the thermal effect of welding, but greater decreases of reduction were actually found.

Unannealed gas and metal arc deposits of weld metal, or branches welded to a tube, tend to stiffen the tube locally and throw tension stresses away from the joint, thus counteracting, to some extent, the thermal effect of welding. This is true even if the weld metal is ground off flush with the tube. This local stiffening of the tube also throws bending and vibration stresses out of the weld into the base metal, the result of which is to greatly increase the reliability of welded joints.

The metal arc welding of tubing directly to another tube of the same size and gage is not considered satisfactory when branches are subject to a very high tensile stress, for the tube to which the branches are welded is liable to split at one-half its ultimate tensile strength. This method of attaching a branch would, however, be satisfactory provided the ultimate tensile strength of the branch tubes was one-half or less than half that of the main tube.

As regards the two methods of welding, metal arc welding is said to be equally as satisfactory as gas welding for airplane construction and has the decided advantage that warping is much less than that produced by gas welding; and the joints can be satisfactorily welded in a jig. (Commander H. B. Bird, U. S. Navy, in *Journal of the American Society of Naval Engineers*, vol. 38, no. 4, Nov., 1926, pp. 879–892, illustrated, *e*)

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Tentative American Standards for Round Unslotted-Head Bolts

IN MARCH, 1922, the American Engineering Standards Committee authorized the organization of a Sectional Committee on the Standardization of Bolt, Nut, and Rivet Proportions. This work is sponsored by the Society of Automotive Engineers and The American Society of Mechanical Engineers.

The Sectional Committee consists of 50 representatives of 29 national organizations and is composed of manufacturers, consumers, and general interests who organized Sub-Committees to standardize on the following:

Rivets
Wrench-Head Bolts and Nuts and Wrench Openings
Slotted-Head Bolts
Track Bolts
Round Unslotted-Head Bolts
Plow Bolts
Body Dimensions and Materials
Nomenclature.

Now that the Sectional Committee has approved the proposed standard on round unslotted-head bolts, it is before the two sponsor bodies for approval and transmission to the American Engineering Standards Committee. Copies of these proposed standards in page-proof form are now available to those especially interested and may be procured by addressing C. B. LePage, Assistant Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y.

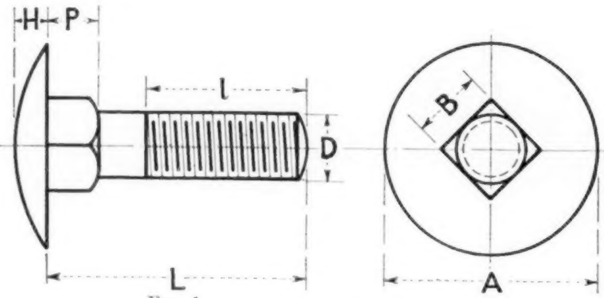


FIG. 1

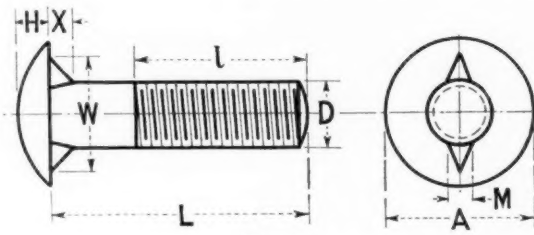


FIG. 2

TABLE 1 SQUARE-NECK CARRIAGE BOLT (See Fig. 1 and also Table 1A)

Nominal size	*D* Major diameter of thread[1] Maximum basic	*D* Tolerance (−)	Threads per inch	*A* Diameter of head Basic	*A* Tolerance (+ or −)	*H* Height of head Basic	*H* Tolerance (+ or −)	*P* Depth of square Basic	*P* Tolerance (+)	*B* Width of square Basic	*B* Tolerance (−)
No. 10	0.190	0.009	24	0.438 (7/16)	0.010	0.094	0.010	0.188	0.031	0.190	0.009
1/4	0.250	0.010	20	0.563 (9/16)	0.010	0.125	0.010	0.219	0.031	0.250	0.010
5/16	0.313	0.013	18	0.688 (11/16)	0.010	0.156	0.010	0.250	0.031	0.313	0.013
3/8	0.375	0.015	16	0.813 (13/16)	0.010	0.188	0.010	0.281	0.031	0.375	0.015
7/16	0.438	0.015	14	0.938 (15/16)	0.010	0.219	0.010	0.313	0.031	0.438	0.015
1/2	0.500	0.015	13	1.063 (1 1/16)	0.010	0.250	0.010	0.344	0.031	0.500	0.015
9/16	0.563	0.016	12	1.188 (1 3/16)	0.015	0.281	0.015	0.375	0.031	0.563	0.016
5/8	0.625	0.017	11	1.313 (1 5/16)	0.015	0.313	0.015	0.406	0.031	0.625	0.017
3/4	0.750	0.020	10	1.563 (1 9/16)	0.015	0.375	0.015	0.469	0.031	0.750	0.020

TABLE 1A

Nominal size	No. 10	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	Length Tolerance (+ or −)
Threads per inch	24	20	18	16	14	13	12	11	10	
Length of bolt (*L*)	Minimum length of thread (*l*) including point									
1/2	T to S	T to S	....	....	....	....	....	....	....	1/64
3/4	3/8	3/8	3/8	3/8	....	....	....	....	....	1/64
1	1/2	1/2	1/2	5/8	5/8	T to S	....	....	....	1/64
1 1/4	1/2	5/8	5/8	5/8	3/4	3/4	T to S	T to S	....	1/64
1 1/2	1/2	3/4	3/4	3/4	7/8	7/8	T to S	T to S	T to S	1/64
1 3/4	5/8	3/4	3/4	3/4	7/8	1	....	....	....	1/64
2	5/8	3/4	3/4	3/4	7/8	1	1 1/4	1 1/4	1 1/4	1/64
2 1/4	5/8	3/4	3/4	3/4	7/8	1	....	....	....	1/64
2 1/2	5/8	3/4	3/4	7/8	7/8	1	1 1/4	1 1/4	1 1/4	1/64
2 3/4	3/4	3/4	7/8	7/8	7/8	1	....	....	....	1/64
3	3/4	3/4	7/8	7/8	7/8	1 1/8	1 3/8	1 3/8	1 1/2	1/64
3 1/4	3/4	3/4	7/8	7/8	1	1 1/8	....	....	....	1/32
3 1/2	3/4	3/4	7/8	7/8	1	1 1/8	1 3/8	1 3/8	1 1/2	1/32
3 3/4	....	3/4	7/8	7/8	1	1 1/8	....	....	....	1/32
4	....	7/8	7/8	7/8	1	1 1/8	1 1/2	1 1/2	1 1/2	1/32
4 1/2	....	7/8	1	1	1 1/8	1 1/4	1 1/2	1 1/2	1 5/8	1/32
5	....	....	1	1	1 1/8	1 1/4	1 1/2	1 1/2	1 5/8	1/32
5 1/2	....	....	1 1/8	1 1/8	1 1/8	1 1/4	1 5/8	1 5/8	1 3/4	1/32
6	....	....	1 1/8	1 1/8	1 1/8	1 1/4	1 5/8	1 5/8	1 3/4	1/32
6 1/2	....	....	1 1/8	1 1/8	1 1/8	1 1/4	1 5/8	1 5/8	1 3/4	1/16
7	....	....	....	1 1/8	1 1/4	1 1/4	1 5/8	1 5/8	1 3/4	1/16
7 1/2	....	....	....	1 1/8	1 1/4	1 1/4	1 5/8	1 5/8	1 3/4	1/16
8	....	....	....	1 1/4	1 1/4	1 3/8	1 5/8	1 5/8	1 7/8	1/16
8 1/2	....	....	....	....	1 1/4	1 3/8	1 3/4	1 3/4	1 7/8	1/16
9	....	....	....	....	1 1/4	1 3/8	1 3/4	1 3/4	2	1/16
9 1/2	....	....	....	....	1 1/4	1 3/8	1 3/4	1 3/4	2	1/16
10	....	....	....	....	1 1/4	1 3/8	1 3/4	1 3/4	2	1/16

"T to S" means threaded to square as near as is practicable.

All dimensions given in inches.

Radius of fillet between body and head 1/32 in. on sizes No. 10 to 1/2 in., inclusive, and 1/16 in. on sizes 9/16, 5/8 and 3/4 in.

All screw threads are to be American Standard, Coarse Thread Series, Free Fit (Class 2) with special major-diameter tolerances provided for unfinished hot-rolled material. (See Table 8, page 16, American Standard Screw Threads B la—1924.)

[1] The threads on these bolts shall be produced by cutting or rolling. When rolled, the shank diameter will necessarily be smaller than the shank diameter for corresponding cut threads.

TABLE 2A

Nominal size	No. 10	1/4	5/16	3/8	7/16	1/2	Length tolerance (+ or −)
Threads per inch	24	20	18	16	14	13	
Length of bolt (*L*)	Minimum length of thread (*l*) including point						
1/2	T to F	T to F	...	...	...	....	1/64
3/4	3/8	3/8	3/8	3/8	...	....	1/64
1	1/2	1/2	1/2	5/8	5/8	T to F	1/64
1 1/4	1/2	5/8	5/8	5/8	3/4	3/4	1/64
1 1/2	1/2	3/4	3/4	3/4	7/8	7/8	1/64
1 3/4	5/8	3/4	3/4	3/4	7/8	1	1/64
2	5/8	3/4	3/4	3/4	7/8	1	1/64
2 1/4	5/8	3/4	3/4	3/4	7/8	1	1/64
2 1/2	5/8	3/4	3/4	3/4	7/8	1	1/64
2 3/4	3/4	3/4	7/8	7/8	7/8	1	1/64
3	3/4	3/4	7/8	7/8	7/8	1 1/8	1/64
3 1/4	3/4	3/4	7/8	7/8	1	1 1/8	1/32
3 1/2	3/4	3/4	7/8	7/8	1	1 1/8	1/32
3 3/4	....	3/4	7/8	7/8	1	1 1/8	1/32
4	....	7/8	7/8	7/8	1	1 1/8	1/32
4 1/2	....	7/8	7/8	1	1 1/8	1 1/4	1/32
5	....	....	1	1	1 1/8	1 1/4	1/32
5 1/2	....	....	1 1/8	1 1/8	1 1/8	1 1/4	1/32
6	....	....	1 1/8	1 1/8	1 1/8	1 1/4	1/32
6 1/2	....	....	1 1/8	1 1/8	1 1/8	1 1/4	1/16
7	....	....	...	1 1/8	1 1/4	1 1/4	1/16
7 1/2	....	....	...	1 1/8	1 1/4	1 1/4	1/16
8	....	....	...	1 1/4	1 1/4	1 3/8	1/16
8 1/2	....	....	...	...	1 1/4	1 3/8	1/16

"T to F" means threaded to fin as near as is practicable.

All dimensions in inches.

Radius of fillet between body and head 1/32 in.

All screw threads are to be American Standard, Coarse-Thread Series, Free Fit (Class 2) with special major-diameter tolerances provided for unfinished hot-rolled material. (See Table 8, page 16, American Standard Screw Threads B la—1924.)

[1] The threads on these bolts shall be produced by cutting or rolling. When rolled, the shank diameter will necessarily be smaller than the shank diameter for corresponding cut threads.

(TABLE 2 FIN-NECK CARRIAGE BOLT (See Fig. 2 and also Table 2A)

Nominal size	*D* Major diameter of thread[1] Maximum basic	*D* Tolerance (−)	Threads per inch	*A* Diameter of head Basic	*A* Tolerance (+ or −)	*H* Height of head Basic	*H* Tolerance (+ or −)	*X* Depth of fins Basic	*X* Tolerance (+)	*W* Distance across fins Basic	*W* Tolerance (+ or −)	*M* Maximum thickness of fins Basic	*M* Tolerance (+ or −)
No. 10	0.190	0.009	24	0.469 (15/32)	0.010	0.078	0.010	0.078	0.010	0.375	0.010	0.078	0.010
1/4	0.250	0.010	20	0.594 (19/32)	0.010	0.109	0.010	0.094	0.010	0.438	0.010	0.094	0.010
5/16	0.313	0.013	18	0.719 (23/32)	0.010	0.141	0.010	0.125	0.010	0.531	0.010	0.125	0.010
3/8	0.375	0.015	16	0.844 (27/32)	0.010	0.172	0.010	0.141	0.010	0.625	0.010	0.141	0.010
7/16	0.438	0.015	14	0.969 (31/32)	0.010	0.203	0.010	0.172	0.010	0.719	0.010	0.172	0.010
1/2	0.500	0.015	13	1.094 (1 3/32)	0.010	0.234	0.010	0.188	0.010	0.813	0.010	0.188	0.010

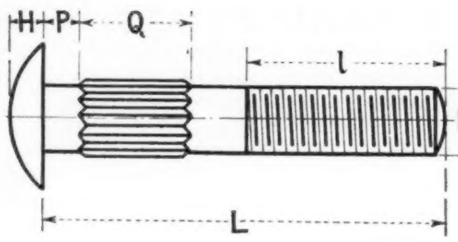


FIG. 3

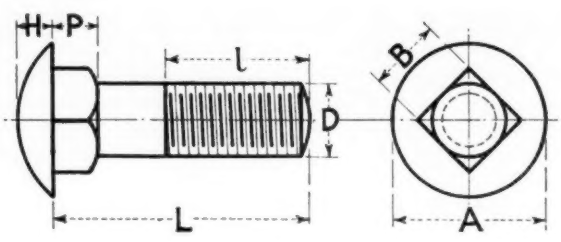


FIG. 4

TABLE 3 RIBBED CARRIAGE BOLT (See Fig. 3 and also Table 3A)

Nominal size	*D* Major diameter of thread[1] Maximum basic	*D* Tolerance (−)	Threads per inch	*A* Diameter of head Basic	*A* Tolerance (+ or −)	*H* Height of head Basic	*H* Tolerance (+ or −)	*P* Distance of rib below head Basic	*P* Tolerance (+ or −)	*Q* Length of rib When *L* is 1 1/8 in. and under	*Q* When *L* is 1 1/4 in. and over	Maximum No. of ribs	Included angle of rib
No. 10	0.190	0.009	24	0.438 (7/16)	0.010	0.094	0.010	0.094	0.031	0.375	0.500	9	Approximately 90 deg.
1/4	0.250	0.010	20	0.563 (9/16)	0.010	0.125	0.010	0.094	0.031	0.375	0.500	10	
5/16	0.313	0.013	18	0.688 (11/16)	0.010	0.156	0.010	0.094	0.031	0.375	0.500	12	
3/8	0.375	0.015	16	0.813 (13/16)	0.010	0.188	0.010	0.094	0.031	0.375	0.500	12	
7/16	0.438	0.015	14	0.938 (15/16)	0.010	0.219	0.010	0.094	0.031	0.375	0.500	14	
1/2	0.500	0.015	13	1.063 (1 1/16)	0.010	0.250	0.010	0.094	0.031	0.375	0.500	16	

TABLE 3A

Nominal size	No. 10	1/4	5/16	3/8	7/16	1/2	
Threads per inch	24	20	18	16	14	13	Length tolerance (+ or −)
Length of bolt (*L*)	Minimum length of thread (*l*) including point						
1	T to R	T to R	T to R	T to R	T to R	T to R	1/64
1 1/4	1/2	5/8	5/8	T to R	T to R	T to R	1/64
1 1/2	1/2	3/4	3/4	3/4	T to R	T to R	1/64
1 3/4	5/8	3/4	3/4	3/4	7/8	1	1/64
2	5/8	3/4	3/4	3/4	7/8	1	1/64
2 1/4	5/8	3/4	3/4	3/4	7/8	1	1/64
2 1/2	5/8	3/4	3/4	3/4	7/8	1	1/64
2 3/4	3/4	3/4	7/8	7/8	7/8	1	1/64
3	3/4	3/4	7/8	7/8	7/8	1 1/8	1/64
3 1/4	3/4	3/4	7/8	7/8	1	1 1/8	1/32
3 1/2	3/4	3/4	7/8	7/8	1	1 1/8	1/32
3 3/4	....	3/4	7/8	7/8	1	1 1/8	1/32
4	....	7/8	7/8	7/8	1	1 1/8	1/32
4 1/2	....	7/8	1	1	1 1/8	1 1/4	1/32
5	....	....	1	1	1 1/8	1 1/4	1/32
5 1/2	....	....	1 1/8	1 1/8	1 1/8	1 1/4	1/32
6	....	....	1 1/8	1 1/8	1 1/8	1 1/4	1/32
6 1/2	....	....	1 1/8	1 1/8	1 1/8	1 1/4	1/16
7	....	....	....	1 1/8	1 1/4	1 1/4	1/16
7 1/2	....	....	....	1 1/8	1 1/4	1 1/4	1/16
8	....	....	....	1 1/4	1 1/4	1 3/8	1/16
8 1/2	....	....	....	....	1 1/4	1 3/8	1/16
9	....	....	....	....	1 1/4	1 3/8	1/16
9 1/2	....	....	....	....	1 1/4	1 3/8	1/16
10	....	....	....	....	1 1/4	1 3/8	1/16

"T to R" means threaded to rib as near as is practicable.
All dimensions in inches.
Radius of fillet between body and head 1/32 in.
All screw threads are to be American Standard, Coarse-Thread Series, Free Fit (Class 2) with special major-diameter tolerances provided for unfinished hot-rolled material. (See Table 8, page 16, American Standard Screw Threads B 1a—1924.)
[1] The threads on these bolts shall be produced by cutting or rolling. When rolled, the shank diameter will necessarily be smaller than the shank diameter for corresponding cut threads.

TABLE 4A

Nominal size	No. 10	1/4	5/16	3/8	7/16	1/2	
Threads per inch	24	20	18	16	14	13	Length tolerance (+ or −)
Length of bolt (*L*)	Minimum length of thread (*l*) including point						
1/2	T to S	T to S	T to S	....	....	....	1/64
3/4	T to S	T to S	T to S	T to S	T to S	....	1/64
1	1/2	1/2	1/2	5/8	5/8	T to S	1/64
1 1/4	1/2	5/8	5/8	5/8	3/4	3/4	1/64
1 1/2	1/2	3/4	3/4	3/4	7/8	7/8	1/64
1 3/4	5/8	3/4	3/4	3/4	7/8	1	1/64
2	5/8	3/4	3/4	3/4	7/8	1	1/64
2 1/4	5/8	3/4	3/4	3/4	7/8	1	1/64
2 1/2	5/8	3/4	3/4	3/4	7/8	1	1/64
2 3/4	3/4	3/4	7/8	7/8	7/8	1	1/64
3	3/4	3/4	7/8	7/8	7/8	1 1/8	1/64
3 1/4	3/4	3/4	7/8	7/8	1	1 1/8	1/32
3 1/2	3/4	3/4	7/8	7/8	1	1 1/8	1/32
3 3/4	....	3/4	7/8	7/8	1	1 1/8	1/32
4	....	7/8	7/8	7/8	1	1 1/8	1/32
4 1/2	....	7/8	1	1	1 1/8	1 1/4	1/32
5	....	....	1	1	1 1/8	1 1/4	1/32
5 1/2	....	....	1 1/8	1 1/8	1 1/8	1 1/4	1/32
6	....	....	1 1/8	1 1/8	1 1/8	1 1/4	1/32
6 1/2	....	....	1 1/8	1 1/8	1 1/8	1 1/4	1/16
7	....	....	....	1 1/8	1 1/4	1 1/4	1/16
7 1/2	....	....	....	1 1/8	1 1/4	1 1/4	1/16
8	....	....	....	1 1/4	1 1/4	1 3/8	1/16
8 1/2	....	....	....	....	1 1/4	1 3/8	1/16

"T to S" means threaded to square as near as is practicable.
All dimensions in inches.
Radius of fillet between body and head 1/32 in.
All screw threads are to be American Standard, Coarse-Thread Series, Free Fit (Class 2) with special major-diameter tolerances provided for unfinished hot-rolled material. (See Table 8, page 16, American Standard Screw Threads B 1a—1924.)
[1] The threads on these bolts shall be produced by cutting or rolling. When rolled, the shank diameter will necessarily be smaller than the shank diameter for corresponding cut threads.

TABLE 4 STEP BOLT (See Fig. 4 and Table 4A)

Nominal size	*D* Major diameter of thread[1] Maximum basic	*D* Tolerance (−)	Threads per inch	*A* Diameter of head Basic	*A* Tolerance (+ or −)	*H* Height of head Basic	*H* Tolerance (+ or −)	*P* Depth of square Basic	*P* Tolerance (+)	*B* Width of square Basic	*B* Tolerance (−)
No. 10	0.190	0.009	24	0.625 (5/8)	0.010	0.094	0.010	0.188	0.031	0.190	0.009
1/4	0.250	0.010	20	0.813 (13/16)	0.010	0.125	0.010	0.219	0.031	0.250	0.010
5/16	0.313	0.013	18	1.000 (1)	0.010	0.156	0.010	0.250	0.031	0.313	0.013
3/8	0.375	0.015	16	1.188 (1 3/16)	0.010	0.188	0.010	0.281	0.031	0.375	0.015
7/16	0.438	0.015	14	1.375 (1 3/8)	0.010	0.219	0.010	0.313	0.031	0.438	0.015
1/2	0.500	0.015	13	1.563 (1 9/16)	0.010	0.250	0.010	0.344	0.031	0.500	0.015

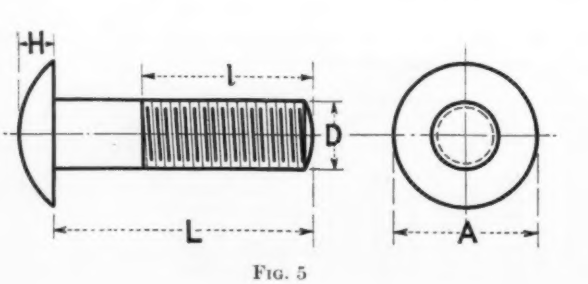


FIG. 5

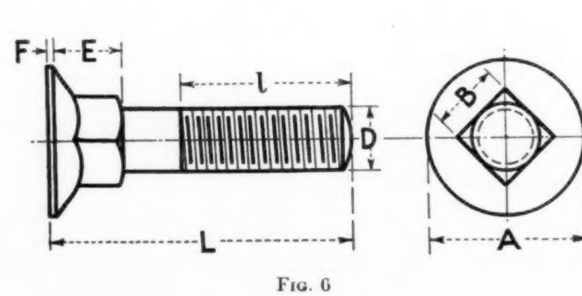


FIG. 6

TABLE 5 BUTTON-HEAD MACHINE BOLT (See Fig. 5)

Nominal size	*D* Major diameter of thread[1] Maximum basic	Tolerance (−)	Threads per inch	*A* Diameter of head Basic	Tolerance (+ or −)	*H* Height of head Basic	Tolerance (+ or −)
No. 10	0.190	0.009	24	0.438 (7/16)	0.010	0.094	0.010
1/4	0.250	0.010	20	0.563 (9/16)	0.010	0.125	0.010
5/16	0.313	0.013	18	0.688 (11/16)	0.010	0.156	0.010
3/8	0.375	0.015	16	0.813 (13/16)	0.010	0.188	0.010
7/16	0.438	0.015	14	0.938 (15/16)	0.010	0.219	0.010
1/2	0.500	0.015	13	1.063 (1 1/16)	0.010	0.250	0.010
9/16	0.563	0.016	12	1.188 (1 3/16)	0.015	0.281	0.015
5/8	0.625	0.017	11	1.313 (1 5/16)	0.015	0.313	0.015
3/4	0.750	0.020	10	1.563 (1 9/16)	0.015	0.375	0.015

Nominal size	No. 10	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	
Threads per inch	24	20	18	16	14	13	12	11	10	Length tolerance
Length of bolt (*L*)	Minimum length of thread (*l*) including point									(+ or −)
1/2	3/8	3/8	3/8	...	...	...	...	...	...	1/64
3/4	3/8	3/8	3/8	3/8	1/2	...	...	...	...	1/64
1	1/2	1/2	1/2	5/8	5/8	3/4	...	...	...	1/64
1 1/4	1/2	5/8	5/8	5/8	3/4	3/4	1	1	...	1/64
1 1/2	1/2	3/4	3/4	3/4	7/8	7/8	1 1/8	1 1/8	1 1/8	1/64
1 3/4	5/8	3/4	3/4	3/4	7/8	1	...	...	...	1/64
2	5/8	3/4	3/4	3/4	7/8	1	1 1/4	1 1/4	1 1/4	1/64
2 1/4	5/8	3/4	3/4	3/4	7/8	1	...	...	...	1/64
2 1/2	5/8	3/4	3/4	7/8	7/8	1	1 1/4	1 1/4	1 1/4	1/64
2 3/4	3/4	3/4	7/8	7/8	7/8	1	...	...	...	1/64
3	3/4	3/4	7/8	7/8	7/8	1 1/8	1 3/8	1 3/8	1 1/2	1/64
3 1/4	3/4	3/4	7/8	7/8	1	1 1/8	...	...	...	1/32
3 1/2	3/4	3/4	7/8	7/8	1	1 1/8	1 3/8	1 3/8	1 1/2	1/32
3 3/4	..	3/4	7/8	7/8	1	1 1/8	...	...	...	1/32
4	..	7/8	7/8	7/8	1	1 1/8	1 1/2	1 1/2	1 1/2	1/32
4 1/2	..	7/8	1	1	1 1/8	1 1/4	1 1/2	1 1/2	1 5/8	1/32
5	..	..	1	1	1 1/8	1 1/4	1 1/2	1 1/2	1 5/8	1/32
5 1/2	..	..	1 1/8	1 1/8	1 1/8	1 1/4	1 5/8	1 5/8	1 3/4	1/32
6	..	..	1 1/8	1 1/8	1 1/8	1 1/4	1 5/8	1 5/8	1 3/4	1/32
6 1/2	..	..	1 1/8	1 1/8	1 1/8	1 1/4	1 5/8	1 5/8	1 3/4	1/16
7	..	..	...	1 1/8	1 1/4	1 1/4	1 5/8	1 5/8	1 3/4	1/16
7 1/2	..	..	...	1 1/8	1 1/4	1 1/4	1 5/8	1 5/8	1 3/4	1/16
8	..	..	...	1 1/4	1 1/4	1 3/8	1 5/8	1 5/8	1 7/8	1/16
8 1/2	..	..	...	...	1 1/4	1 3/8	1 3/4	1 3/4	1 7/8	1/16
9	..	..	...	...	1 1/4	1 3/8	1 3/4	1 3/4	2	1/16
9 1/2	..	..	...	...	1 1/4	1 3/8	1 3/4	1 3/4	2	1/16
10	..	..	...	...	1 1/4	1 3/8	1 3/4	1 3/4	2	1/16

All dimensions in inches.

Radius of fillet between body and head 1/32 in. on sizes No. 10 to 1/2 in., inclusive and 1/16 in. on sizes 9/16, 5/8 and 3/4 in.

All screw threads are to be American Standard, Coarse-Thread Series, Free Fit (Class 2) with special major-diameter tolerance provided for unfinished hot-rolled material. (See Table 8, page 16, American Standard Screw Threads B 1a—1924.)

[1] The threads on these bolts shall be produced by cutting or rolling. When rolled, the shank diameter will necessarily be smaller than the shank diameter for corresponding cut threads.

TABLE 6 COUNTERSUNK CARRIAGE BOLT (See Fig. 6)

Nominal size	*D* Major diameter of thread[1] Maximum basic	Tolerance (−)	Threads per inch	*A* Diameter of head Basic	Tolerance (+ or −)	*F* Feed thickness	Included angle (deg.)	*E* Depth of square Basic	Tolerance (+)	*B* Width of square Basic	Tolerance (−)
No. 10	...	...	..	......	...	...	...	...	...	...	...
1/4	0.250	0.010	20	0.625 (5/8)	0.010	0.016	114	0.281	0.031	0.250	0.010
5/16	0.313	0.013	18	0.750 (3/4)	0.010	0.031	114	0.344	0.031	0.313	0.013
3/8	0.375	0.015	16	0.875 (7/8)	0.010	0.031	114	0.406	0.031	0.375	0.015
7/16	0.438	0.015	14	1.000 (1)	0.010	0.031	114	0.469	0.031	0.438	0.015
1/2	0.500	0.015	13	1.125 (1 1/8)	0.010	0.031	114	0.531	0.031	0.500	0.015
9/16	0.563	0.016	12	1.250 (1 1/4)	0.015	0.031	114	0.594	0.031	0.563	0.016
5/8	0.625	0.017	11	1.375 (1 3/8)	0.015	0.031	114	0.656	0.031	0.625	0.017
3/4	0.750	0.020	10	1.625 (1 5/8)	0.015	0.047	114	0.781	0.031	0.750	0.020

Nominal size	No. 10	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	
Threads per inch	24	20	18	16	14	13	12	11	10	Length tolerance
Length of bolt (*L*)	Minimum length of thread (*l*) including point									(+ or −)
3/4	T to S	T to S	T to S	T to S	T to S	...	...	...	...	1/64
1	1/2	1/2	1/2	T to S	T to S	T to S	...	...	...	1/64
1 1/4	1/2	5/8	5/8	5/8	T to S	T to S	T to S	T to S	...	1/64
1 1/2	1/2	3/4	3/4	3/4	7/8	T to S	T to S	T to S	T to S	1/64
1 3/4	5/8	3/4	3/4	3/4	7/8	1	...	...	...	1/64
2	5/8	3/4	3/4	3/4	7/8	1	1 1/4	T to S	T to S	1/64
2 1/4	5/8	3/4	3/4	7/8	7/8	1	...	...	...	1/64
2 1/2	5/8	3/4	3/4	7/8	7/8	1	1 1/4	1 1/4	1 1/4	1/64
2 3/4	3/4	3/4	7/8	7/8	7/8	1	...	...	...	1/64
3	3/4	3/4	7/8	7/8	7/8	1 1/8	1 3/8	1 3/8	1 1/2	1/64
3 1/4	3/4	3/4	7/8	7/8	1	1 1/8	...	...	...	1/32
3 1/2	3/4	3/4	7/8	7/8	1	1 1/8	1 3/8	1 3/8	1 1/2	1/32
3 3/4	...	3/4	7/8	7/8	1	1 1/8	...	...	...	1/32
4	...	7/8	7/8	7/8	1	1 1/8	1 1/2	1 1/2	1 1/2	1/32
4 1/2	...	7/8	1	1	1 1/8	1 1/4	1 1/2	1 1/2	1 5/8	1/32
5	...	...	1	1	1 1/8	1 1/4	1 1/2	1 1/2	1 5/8	1/32
5 1/2	...	...	1 1/8	1 1/8	1 1/8	1 1/4	1 5/8	1 5/8	1 3/4	1/32
6	...	...	1 1/8	1 1/8	1 1/8	1 1/4	1 5/8	1 5/8	1 3/4	1/32
6 1/2	...	...	1 1/8	1 1/8	1 1/8	1 1/4	1 5/8	1 5/8	1 3/4	1/16
7	...	...	...	1 1/8	1 1/4	1 1/4	1 5/8	1 5/8	1 3/4	1/16
7 1/2	...	...	...	1 1/8	1 1/4	1 1/4	1 5/8	1 5/8	1 3/4	1/16
8	...	...	...	1 1/4	1 1/4	1 3/8	1 5/8	1 5/8	1 7/8	1/16
8 1/2	...	...	...	...	1 1/4	1 3/8	1 3/4	1 5/8	1 7/8	1/16
9	...	...	...	...	1 1/4	1 3/8	1 3/4	1 3/4	2	1/16
9 1/2	...	...	...	...	1 1/4	1 3/8	1 3/4	1 3/4	2	1/16
10	...	...	...	...	1 1/4	1 3/8	1 3/4	1 3/4	2	1/16

"T to S" means threaded to square as near as is practicable.

All dimensions in inches.

Radius of fillet between body and head 1/32 in. on sizes No. 10 to 1/2 in., inclusive, and 1/16 inch on sizes 9/16, 5/8 and 3/4 in.

All screw threads are to be American Standard, Coarse-Thread Series, Free Fit (Class 2) with special major-diameter tolerances provided for unfinished hot-rolled material. (See Table 8, page 16, American Standard Screw Threads B 1a—1925.)

[1] The threads on these bolts shall be produced by cutting or rolling. When rolled, the shank diameter will necessarily be smaller than the shank diameter for corresponding cut threads.

A.S.M.E. Boiler Code Committee Work

The Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in the Society's journal, MECHANICAL ENGINEERING.

Below are given interpretations of the Committee in Cases Nos. 530, 534 and 535, as formulated at the meeting of October 29, 1926, all having been approved by the Council. In accordance with established practice, the names of the inquirers have been omitted.

CASE NO. 530

Inquiry: Is it permissible under the Code, to consider that the autogenous welding of the flanges which form the fire-door opening of a vertical fire-tube boiler, is supported by other construction as required by Par. P-186, inasmuch as the furnace itself is self-supporting and the weld is further reinforced by virtue of the increased stiffness given to it by the surrounding flanges formed with the furnace and shell plates?

Reply: The Committee has expressed the opinion in Case No. 252, that where the furnace and exterior sheets are stayed or otherwise supported around the door-hole opening and provided that the distance from the flange to the surrounding row of stays or other supports does not exceed the permissible staybolt pitch specified in Par. P-199, such welding of the door-hole flanges is permissible. In cases of furnace construction which under Pars. P-239 and P-240 are permitted to be built without staybolting, it is the opinion of the Committee that unless there are other means provided to relieve the welding of the flanges from stress as specified in Par. P-186, such welding of the door-hole flanges is not permissible.

CASE NO. 534

Inquiry: Is it permissible under the requirements of the Code, to rivet a cast-steel ell, of dimensions complying with Table A-6, to the bottom of a shell or drum of water-tube, tubular, or waste-heat boilers, for the blow-off connection, when the operating pressure is 175 lb. per sq. in. or over?

Reply: The Code does not prohibit the riveting of steel castings to the shell.

CASE NO. 535

Inquiry: Is it permissible, under the requirements of Par. P-216 of the Code, to consider the bounding edges of furnace openings in Scotch-type boilers as the equivalent of groups of tubes in applying the extended pitch allowances adjacent to the shell?

Reply: It is the opinion of the Committee that in the application of the provisions in Par. P-216 for extension of staybolt pitch allowances, the furnaces of Scotch-type boilers if riveted to flanged openings in the head, may be considered as the equivalent of tubes in the reinforcement thereof. Attention is called, however, to the requirement in the last sentences of Par. P-216 which, under the conditions above referred to, will apply to adjacent edges of the tube and furnace to which the common tangent may be drawn.

Engineering and Industrial Standardization

Steps in Progress Recorded at 1926 Annual Meeting of the A.S.M.E.

Meeting of Standing Committee

THE A.S.M.E. Standardization Committee held a two-session meeting during which the progress and present status of all of the projects for which the Society is sponsor or joint sponsor were reviewed, and the Committee was gratified at the results so far attained.

During the meeting a number of matters of policy were fully discussed and many new standardization projects in the field of Mechanical Engineering were considered. The Committee finally voted to recommend to the A.S.M.E. Council the initiation of six new projects. Brief notes on these projects are given below.

Pipe Thread. The American Standard (Briggs) for pipe thread was completed in 1919 by a Sectional Committee organized under the procedure of the American Engineering Standards Committee. It was then published under the designation A.E.S.C. No. B2–1919. Recently, however, the need for a revision of this pamphlet has been expressed a number of times, so a new Sectional Committee will be organized to undertake this task.

Standards for Wrought-Iron and Steel Pipe. On the recommendation of the A.S.M.E. Standardization Committee, which approved the action of the Sectional Committee on the Standardization of Pipe Flanges and Fittings, the A.S.M.E. Council voted on December 10 to request the A.E.S.C. to authorize the standardization under its procedure of the dimensions and material of wrought-iron and steel pipe. It is of course recognized that practically all of the dimensional data are now available in one form or another, and that the material specifications are covered by A.S.T.M. Specifications Nos. A72-24, A53-24 and A106-26 T. There seems to be a need however, for a coördinated review of these data and for their submission to the A.E.S.C. as one document for approval as an American Standard.

Plumbing Fixtures and Fittings. The A.S.M.E. Standardization Committee has been urged to consider the standardization of the essential interchangeable features of plumbing fixtures and fittings. After a preliminary study of this project the Committee decided to recommend it to the A.S.M.E. Council, after the Committee had made a few additional inquiries.

Face-to-Face Dimensions of Flanged Valves. The fact that the manufacturers of steel valves for steam pressures of 400, 600, 900, and 1350 lb. have agreed to make them with face-to-face dimensions equal respectively to the corresponding dimensions of the new series of steel fittings for these pressures, has encouraged the members of the A.S.M.E. Standardization Committee to believe that in time the standardization of the face-to-face dimensions of all flanged globe, angle, gate, and check valves for pressures which are covered by the new cast-iron and steel flanged fitting standards might be accomplished. They have accordingly voted to recommend this project also to the A.S.M.E. Council.

Fire- and Small-Hose Couplings. In May, 1925, the American Engineering Standards Committee approved as an "American Standard" the screw threads of the fire-hose couplings developed in their elementary form by a committee of the National Fire Protection Association and now sponsored jointly by the American Water Works Association, the National Board of Fire Underwriters, and The American Society of Mechanical Engineers under the procedure of the A.E.S.C. These standard screw threads are for all connections having nominal inside diameters of $2^1/_2$, 3, $3^1/_2$, and $4^1/_2$ in.

Previous to that date in June, 1924, a set of standard specifications for the external dimensions of fire-hose couplings had been recommended jointly by the Specification Committee of the Mechanical Rubber Goods Manufacturers' Division of the Rubber Association of America and the Hose Fittings Manufacturers Association.

In 1920 a committee of the National Fire Protection Association submitted a report on the standardization of the screw threads for couplings having nominal inside diameters of $^1/_2$, $^3/_4$, 1, $1^1/_4$, $1^1/_2$, and 2 in. It was tentatively adopted by the Association that year and finally adopted with slight changes the following year. This report does not, however, include the necessary limits for the dimensions affecting interchangeability.

The 1921 and 1924 reports of the National Screw Thread Commission contain fully developed series of dimensions for the screw threads of small-hose couplings, $^1/_2$ to 2 in. and inclusive. The pitches of these threads and other principal dimensions vary from the standards proposed by the N.F.P.A.

The A.S.M.E. Standardization Committee has carefully considered this situation and on December 8 voted to recommend to the A.S.M.E. Council that it authorize the Committee to make an attempt to unify and standardize the screw threads and external dimensions of hose couplings throughout the entire range from $^1/_2$ to $4^1/_2$ inches.

Screw Threads for Rigid Electrical Conduit. It is generally understood that the screw threads on rigid electrical conduit conform in pitch to the American Standard for Pipe Thread. Some difficulty has been experienced, however, by those who supply lock-nuts, bushings and other types of fittings used on this rigid conduit owing to the lack of specified gaging limits on the conduit and fitting thread.

The A.S.M.E. Standardization Committee has had this situation called to its attention a number of times and has finally decided to recommend that this subject be made a standardization project under the procedure of the A.E.S.C. The Committee is, of course, acquainted with the incomplete specification prepared by the Underwriters' Laboratories now in general use and with the specification of the Federal Specifications Board which is virtually a copy of the former. It knows, also, that the National Screw Thread Commission has studied this subject. There seems, however, to be good reason for unifying and completing this threading practice in a way which would establish it as an American Standard.

Small Tools and Machine Elements

Taper Keys. Sub-Committee No. 4 of the Sectional Committee on the Standardization of Shafting met on December 7 to consider the comments which had been received as a result of the general distribution of page proofs of its proposed reports on standards for plain and gib-head taper keys.

After some discussion of the points raised, the Committee voted to transmit these two proposed standards to the Sectional Committee for discussion and vote, after which, on approval, they will be submitted to The American Society of Mechanical Engineers as sponsor society for this project.

Plain and Lock Washers. On Wednesday, December 8, the Sectional Committee which was recently appointed to unify the present dimensions of plain and lock washers advanced both sides of this project a considerable distance. The Manufacturers' Committee on lock washers had previously submitted for distribution to the members of the Sectional Committee a recommendation covering the revision and extension of the present S.A.E. Standard. This report was fully discussed, and after certain changes and eliminations had been made the Secretary was directed to put the proposed standard in type and distribute it generally for criticism and comment.

A Sub-Group also formulated a table of dimensions for round plain washers, which will soon be distributed generally for criticism and comment.

While the personnel of the Sectional Committee at the present time is not complete, it now consists of:

- Victor E. Bertrandias, *Temporary Chairman*, representing U. S. War Department.
- H. A. Hoke, *Temporary Secretary*, representing American Railway Association.
- Fred Doepke, representing American Hardware Manufacturers Association.

A. H. FETTERS, representing American Railway Association.
C. S. GILLETTE, Commander, representing U. S. Navy Department, Bureau of Engineering.
J. HOWARD HORN, representing Standards Committee of the Lock Washer Industry.
J. J. MCBRIDE, representing American Railway Car Institute.
HENRY C. E. MEYER, representing American Marine Standards Committee.
JAMES S. MILNE, representing Society of Naval Architects and Marine Engineers.
WILLIAM J. OUTCALT, representing Society of Automotive Engineers.
CLEARENCE W. SQUIER, representing American Electric Railway Association.
H. N. WALLIN, LIEUT., representing U. S. Navy Department, Bureau of Construction and Repair.
OLIVER B. ZIMMERMAN, representing American Society of Agricultural Engineers.

Woodruff Keys. During the past year Sub-Committee No. 5 of the Sectional Committee on the Standardization of Shafting has made real progress toward the unification and standardization of American practice in the manufacture and use of Woodruff keys. The meeting of the Sub-Committee held on December 8 was given over almost entirely to a discussion of the subject of tolerances on the key and the keyway. No final action was taken, however, pending further consideration of the comments written by those who had received page proofs of the Committee's proposed set of dimensions of Woodruff keys.

The membership of this Committee at present is:

WILLIAM J. OUTCALT, *Chairman*, representing the S.A.E.
L. C. MORROW, *Secretary*, representing the A.S.M.E.
S. W. BURLINGAME, representing Manufacturers.
S. N. CLARKSON, representing Electric Power Club.
RICHARD F. DOW, representing Manufacturers.
K. L. HERRMANN, representing the S.A.E.
T. S. HOMANS, representing the A.S.M.E. Printing Division.
E. P. MERRILL, representing Manufacturers.
J. L. MOULTROP, representing Manufacturers.
C. J. OXFORD, representing Manufacturers.
EUGENE C. PECK, representing A.S.M.E.
C. W. SPICER, representing Society of Automotive Engineers.
B. D. Stevens, representing American Society of Mechanical Engineers, Printing Division.
C. H. VAUGHAN, representing Manufacturers.
E. J. WAGNER, representing Manufacturers.
OLIVER B. ZIMMERMAN, representing National Association of Farm Equipment Manufacturers.

Transmission Chains and Sprockets. Several months ago the A.E.S.C. authorized the reorganization of the three committees on Roller Chains and Sprockets into one Sectional Committee on Transmission Chains and Sprockets. These three committees had been formed, respectively, by the American Gear Manufacturers Association, the S.A.E., and the A.S.M.E. At the same time these organizations were designated as joint sponsors for this project.

At the first meeting of the Sectional Committee which was held on December 10 the time was spent in the election of temporary officers, the naming of Sub-Committees, and a brief discussion of the progress previously made by the three separate committees. Reports of the A.S.M.E. Committees will be found in MECHANICAL ENGINEERING, September, 1921, and August, 1923.

The Sectional Committee on the Standardization of Transmission Chains now consists of:

F. V. HETZEL, *Temporary Chairman*, representing American Society of Mechanical Engineers.
G. M. BARTLETT, *Temporary Secretary*, representing American Society of Mechanical Engineers.
F. J. OAKES, representing American Gear Manufacturers Association.
H. H. KERR, representing American Gear Manufacturers Association.
C. R. WEISS, representing American Petroleum Institute.
E. M. KARR, representing American Petroleum Institute.
L. V. LUDY, representing American Petroleum Institute.
E. B. NICHOLS, representing American Petroleum Institute.
H. E. MCCRAY, representing National Farm Equipment Manufacturers Association.
W. J. BELCHER, representing Society of Automotive Engineers.
D. B. BAKER, representing Society of Automotive Engineers.
W. F. COLE, representing Societ of Automotive Engineers.
CHAS. FROESCH, representing Society of Automotive Engineers.
G. A. YOUNG, representing Society of Automotive Engineers.
JOS. JOY, Independent Expert from Hans Renold, Inc.
F. L. MORSE, Independent Expert from Morse Chain Company.
J. H. RAMSEY, Independent Expert from Ramsey Chain Company, Inc.

Milling Cutters. One of the best-attended meetings of the technical committee group during the week December 6 to 10 was that on the Standardization of Milling Cutters. The Committee was organized at this meeting and elected C. W. Machon as Temporary Chairman and H. C. Hungerford as Temporary Secretary.

The formation of seven Sub-Groups was agreed upon and their personnel determined as follows:

No. 1—Profile Cutters. Thomas R. Jones, *Chairman*, Archibald N. Goddard and C. W. Machon.

No. 2—Keyways. Joseph B. Armitage, *Chairman*, Francis S. Walters and H. C. Hungerford.

No. 3—Nomenclature. A. C. Danekind, *Chairman*, Erik Oberg and Archibald N. Goddard.

No. 4—Limits. J. H. Horigan, *Chairman*, H. C. Smith and Thomas R. Jones.

No. 5—Form Cutters. H. C. Hungerford, *Chairman*, F. G. Hoffman and Frederick R. Stevens.

No. 6—Hobs. George L. Markland, Jr., *Chairman*, W. F. Zimmerman and Earle D. Parker.

No. 7—Inserted-Tooth Cutters. Joseph B. Armitage, *Chairman*, E. K. Morgan and Frederick R. Stevens.

To date the personnel of this Sub-Committee is as follows:

C. W. MACHON, *Temporary Chairman*, representing the Milling Cutter Society.
H. C. HUNGERFORD, *Temporary Secretary*, representing Milling Cutter Society.
J. B. ARMITAGE, representing National Machine Tool Builders Association.
A. C. DANEKIND, Independent Expert from General Electric Company.
A. N. GODDARD, representing The American Society of Mechanical Engineers.
E. G. HERNDON, representing U. S. Navy Department.
F. G. HOFFMAN, representing Milling Cutter Society.
T. R. JONES, representing National Machine Tool Builders Association.
G. L. MARKLAND, Jr., representing American Gear Manufacturers Association.
ERIK OBERG, representing The American Society of Mechanical Engineers.
C. J. OXFORD, representing the Milling Cutter Society.
F. R. STEVENS, representing The American Society of Mechanical Engineers
T. C. VAIL, representing The American Society of Mechanical Engineers.
F. S. WALTERS, Independent Expert from Westinghouse Electric & Mfg. Co.

Correspondence

CONTRIBUTIONS to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on activities or policies of the Society in Research and Standardization.

The Strength of Gear Teeth

TO THE EDITOR:

In the November, 1926, issue of MECHANICAL ENGINEERING there appeared on pages 1105–1109 a paper entitled The Strength of Gear Teeth, by S. Timoshenko and B. V. Baud. This is for the most part an excellent and instructive paper, and it is too bad to have to point out that the authors have failed to call attention to previously published work which almost exactly covers part of their studies. This previous work is published in the Transactions of the A.S.M.E. and of the American Society for Steel Treating[1] and has been reprinted and reviewed by other magazines.

The authors' conclusion that the effect of shrink-fit pressures may be neglected certainly not generally true, especially in the case of small highly stressed pinions, as shown by test outlined in the references cited.

ARTHUR L. KIMBALL.[2]

Schenectady, N. Y.

[1] Stress Distribution in Electric Railway Motor Pinions as Determined by the Photoelastic Method, P. Heymans, and A. L. Kimball, Jr., Trans. A.S.M.E., vol. 44 (1922), p. 513.

The Photoelastic Method for the Determination of Causes of Failure of Metal Structures, P. Heymans, G. R. Brophy, and A. L. Kimball, Jr., Trans. Am. Soc. for Steel Treating, 1924.

[2] Research Engineer, General Electric Co., Assoc. A.S.M.E.

The Conference Table

THIS Department is intended to afford individual members of the Society an opportunity to exchange experience and information with other members. It is to be understood, however, that questions which should properly be referred to a consulting engineer will not be handled in this department.

Inquiries will be welcomed at Society headquarters, where they will be referred to representatives of the various Professional Divisions of the Society for consideration. Replies are solicited from all members having experience with the questions indicated. Replies should be as brief as possible. Among those who have consented to assist in this work are:

ARCHIBALD BLACK,
Aeronautic Division
H. W. BROOKS,
Fuels Division
R. L. DAUGHERTY,
Hydraulic Division
JAMES A. HALL,
Machine-Shop Practice Division
CHARLES W. BEESE,
Management Division
G. E. HAGEMANN,
Materials Handling Division
J. L. WALSH,
National Defense Division
L. H. MORRISON,
Oil and Gas Power Division
W. R. ECKART,
Petroleum Division
F. M. GIBSON and W. M. KEENAN,
Power Division
WINFIELD S. HUSON,
Printing Machinery Division
MARION B. RICHARDSON,
Railroad Division
JAMES W. COX, JR.,
Textile Division
WM. BRAID WHITE,
Wood Industries Division

Aeronautics

Municipal Flying Field Size[1]

A-7 What size of plot is required for a municipal flying field?

A really good flying field should have runways in at least two directions, preferably as near at right angles as possible, each runway to be not less than 2000 ft. long with clear approaches at both ends. It is true, however, that some municipal flying fields are smaller than this and are in every-day use. Several cities, such for example, as St. Paul, Minn., and Hartford, Conn., have fields between 3000 and 4000 ft. long. It would be a mistake to make municipal landing fields too small, so that with increasing air traffic they would be congested. One of the runways should run as nearly as possible in the direction of the prevailing wind. To give an example of a municipal flying field smaller than the above dimensions, the Boston Airport has two runways in the form of the letter "T," each runway being 1500 ft. long. The field is laid out on filled-in land and has free approaches from every side. It is a very good field and is used a great deal. (Richard H. Depew, Vice-President, Fairchild Flying Corporation, New York, N. Y.)

Aerial Surveys

A-8 To what extent can aerial surveys be used to determine elevation contours in right-of-way studies? What degree of accuracy is attainable?

Theoretically, absolutely accurate elevation contours can be determined by aerial photographic surveys. Such contours are based on the very accurate measurements of extremely small distances on the negatives. Errors of 0.001 in. in such measurements will affect the accuracy of the final contours. The writer believes that a direct answer to the question would be that a very high degree of accuracy is attainable and that aerial surveys can be used to determine all the elevation contours in right-of-way studies that may be required. The cost, however, is so high that, as a result, the writer believes that it is not practicable to secure accurate elevation contours in this manner. By combining aerial photographic surveys with a minimum of ordinary ground work and a considerable amount of study and good judgment on the part of the locating engineer, practically the same information can be obtained cheaply. By using the aerial photographs (ordinary contact prints) under the stereoscope, the highest and lowest points in any area and the relative heights of all hills, slopes, etc., can be determined. Although the photographs give neither contours nor any definite accuracy, as regards elevations, they serve a better purpose. They enable the engineer to study conditions as if he were sitting still in the air directly over the actual ground. The benefits derived therefrom depend upon his knowledge of geography and his judgment. It is necessary for him to follow this study by certain surveys on the ground, especially the location survey, but the cost of this work, due to his ability to make definite plans and limit the ground work to the areas requiring careful attention, will in most cases save many times the cost of the aerial photographs required. (E. R. Polley, General Manager, Fairchild Aerial Surveys, New York, N. Y.)

[1] This subject has been discussed in a previous issue.

Fuels

Lime-Kiln Efficiencies

F-7 What are the usual figures for efficiencies of lime kilns, what is considered good practice and what attention should be given to insure maximum results?

As low as 20 per cent and occasionally as high as 50 per cent. An efficiency of 45 per cent is exceptionally good practice. Attention should be given to regular supply of gas, proper proportion of air, elimination as far as possible of radiation, proper distribution of gas in the kiln, and the elimination of any agent tending to transfer heat content from high to low level, such as steam, for example. (Victor J. Azbe, Consulting Engineer, St. Louis, Mo.)

Tempering Coal

F-8 What experience have members had with "tempering" or wetting down coal?

Tempering is very desirable with mid-western coals. Combustion rates are increased, carbon in ash is reduced, CO_2 is slightly improved and siftings through the grate reduced. (T. A. Marsh, Western Engineer, Combustion Engineering Corp., Chicago, Ill.)

Overcoming Spontaneous Combustion

F-9 What has been the experience with and means utilized for overcoming spontaneous combustion in stored coal?

The excellent work of Professor Stoek of Illinois University covers this question thoroughly. Coal of uniform size stores best. Building storage piles in layers is important. Sometimes all known rules fail and a carelessly stored pile will not ignite, while occasionally the most carefully stored pile ignites. (T. A. Marsh, Western Engineer, Combustion Engineering Corp., Chicago, Ill.)

Machine-Shop Practice

Fitting a Loose Pulley to a Shaft

MS-4 The bore of a pulley is too small to accomodate the shaft upon which it will run loose. Is it recommended that the cold-drawn shaft be turned to fit, or is it better to rebore the pulley and thereby preserve the hardened "skin" of the shafting.

(*a*) The method will depend entirely upon size and conditions. Under ordinary conditions it is easier to make a fit by turning, filing or grinding the shaft than it is to bore the hole to size. The life or wearing qualities of the job will not depend so much upon the hard "skin" of the cold-drawn shaft as it will upon smoothness of surfaces, proper allowance in diameters and proper lubrication in early life. (W. P. Turner, Professor, Practical Mechanical Engineering, Purdue University.)

(*b*) The original "skin" formed on cold-drawn steel shafting is important from its tendency to induce deformation of the shaft when

cut into, rather than from any better wearing qualities. This tendency to warp is more marked when such work as keyseating is done on the shaft than when it is turned down in a concentric manner. Therefore it will usually be satisfactory to turn down the shaft to fit the bore of the pulley in such a case as set forth, rather than rebore the pulley. In doing this the new surface should be smoothed carefully to furnish a good bearing surface and the shaft should be carefully straightened if warping followed the process of machining off some of the "skin." (G. H., New York, N. Y.)

Management

Code of Best Practice

MG-1 What have been the observations and experiences of members in the matter of time studies and what opinions have been formed regarding the advisability or possibility of evaluating the various factors involved, looking toward the development of a "Code of Best Practice?"

(*a*) A great deal has been written on the subject and thousands of plants are using time study as a basis for rate setting. There seems to be a feeling among beginners that if rate setting is done through the use of a stop watch, the rates are correct. This belief is not shared by thousands of workers who work under the rates set by time-study experts, so called, nor by many executives who watch the costs of different lots in manufacture. The writer does not wish to have it understood that he is indicting all time-study experts, for some good work is being done, but every week one sees the need for enlightenment of the time-study expert on the best practice, also the executive who retains the expert, and the worker himself. Results would be twofold. The expert would be able to do his work right, which would result in correct wages, these in turn inspiring confidence on the parts of the executive and the worker. The writer's personal opinion is that a collection of general time-study information will not be of much value in an attempt to formulate a code. This can best be developed by men with years of experience in this work. Some one person with years of experience who is heart and soul in the work must father the proposition and see that the details are developed properly. (William O. Lichtner, Treasurer, Thompson and Lichtner Co., Boston, Mass.)

(*b*) Taylor hoped to so standardize time-study procedure that there could be prepared a series of handbooks establishing standards once for all, for all classes of work. Toward the end of his life he learned that this was next to impossible from the fact that his own men did not in the least agree in their methods or the standards which they derived. The idea of standardized methods, regardless of different conditions, is still a mirage to many. It is the writer's belief that the principles involved are about the only portions acceptable alike by all. The allowances might be improved by wider elucidation, although the writer believes that the tendency to set an arbitrary allowance of, say, 25 per cent, or even 40 per cent, on everything is becoming uncommon.

Fundamentally, Gilbreth's and Merrick's allowances are alike. They both come from actual experience covering years of tryout and perhaps several operatives. Merrick plots such data by classes and develops a curve based on the mode principle and repeats this for each 10 per cent variation in the proportion between handling and machining time. There is no doubt that the shape of these curves is according to two laws of work, roughly stated as follows:

First, the shorter the handling cycle, the higher the allowance for delay. This is no doubt due to the energy required to overcome the inertia of starting these cycles frequently, whereas in the longer cycles the operation continues under a sort of momentum.

Second, the smaller the percentage of handling time the higher the allowance. Similar to the first principle, this probably is due to the fact that the more the machine is running in cycle the greater the mechanical influence to keep the job.

Gilbreth divided his allowances without such curves, but by making comparisons between new and old studies. This method was sufficiently refined to enable him to select some one therblig or perhaps a small group of therbligs which would be identical in some older study. He would then determine the characteristics of the new work relative to the old and tried and thus prorate all therbligs to the desired allowed time.

While it is difficult for an employer to use either of these methods, the writer believes that it is worth while for each to spend some study on allowances for their particular classes of work. A number have followed Merrick's lead, resulting in formulas different from his only in the value of the constants. Merrick's method of classifying times according to the nature of the motions involved rather than by mere machines enabled him to make synthetic time studies of almost anything in the machine-shop line. (Chas. W. Lytle, Director of Industrial Coöperation, New York University.)

Textile

Materials-Handling Equipment

T-6 In line with the question involving conveying and hoisting equipment, discussed in the November and December, 1926, issues of Mechanical Engineering, what types of materials-handling equipment are best suited to the various operations encountered in a modern textile plant?

In handling the cotton we have the overhead trolley or truck, the combined truck and piler system, the latter being used quite extensively where the cotton in the bale has to be piled two or three tiers deep in the stock room.

For handling the yarn, we find the belt conveyor and the roller conveyor the most prominent in the better-equipped mills. Many of the older ones use the old truck system. The belt or roller conveyor, in combination with the tote box or container, seems to be best adapted for the handling of the yarn in bobbin or cone, the container being constructed either of metal, or of metal with a canvas lining.

In the handling of warps from the slasher to the loom, the overhead trolley or truck system seems the most generally used. Each of these has its advantages and the question of which is best adapted for the mill must be settled by a study of conditions. The same system is used for conveying the cloth from the loom to the cloth room.

Beside these, we have the gravity system in its various forms. However, any system which depends upon a sliding of the cloth along gravity chutes is questionable in many cases, for the reason that contact with the sides of the chute has a tendency to soil the cloth. The belt conveyor and the roller conveyor have the same objection, but it is in a large measure overcome by careful supervision of the sides of the chutes. The overhead trolley or the truck, conveying two or four cuts of cloth, seem to be best adapted for most mill conditions.

From the cloth room to the bleachery or finishing plant the truck or overhead trolley system seems to be productive of greatest cleanliness, and at the same time, is fully as flexible as any system which has been brought to the writer's attention. The truck may be a special three- or four-caster truck of box or rack form, the rack being arranged to hold three or four rolls of cloth, according to the width of the cloth and the size of the rolls.

The truck system, in which a plain truck of the railway type is used, has been supplanted in may of the mills by the free-running truck arranged so that it can be easily directed from one machine to another. The box type of truck, however, with a canvas or duck container, is used for conveying bobbins or spools.

The belt conveyor, when practical to use, with a tote box or container, has proved very efficient, and except with very fine goods, there is very little liability of damaging goods in transit. The roller system is very satisfactory when the goods or the stock can be well protected by a container.

Regarding the installation of any conveyor system, a careful study must be made of the conditions under which the conveyor is to be used, and at the same time, a study of the distance that the stock must be carried and whether a long-range type of conveyor or a series of three or four short-range conveyors would be most advantageous.

It is difficult to outline any system without a very thorough study of the conditions, and expressions of opinion based on the experiences of members of the Society should prove helpful to the engineer in his efforts to improve textile materials-handling equipment. (E. H. Marble, President, Curtis and Marble Machine Co., Worcester, Mass.)

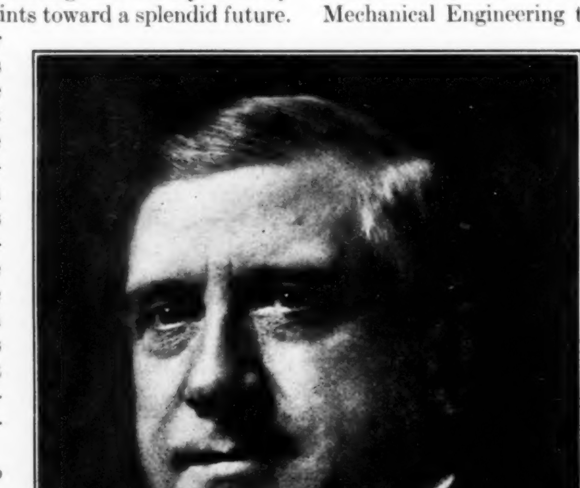
Forty-Seventh Annual Meeting of the A.S.M.E.

All Attendance Records Broken—Unusual Pressure of Technical Sessions and Social Events Precludes Customary All-Day Excursion—President Charles M. Schwab Assumes Duties with Keen Enthusiasm

THE FORTY-SEVENTH Annual Meeting of The American Society of Mechanical Engineers has now gone into history as another memorable event in the constantly broadening activities of the Society. It is forcibly brought out as one considers this as the Forty-Seventh Meeting, that the fiftieth anniversary of the A.S.M.E. is close at hand. The meeting was worthy in every way of the traditions behind it, and points toward a splendid future.

A registration of 2213 for the four days December 6 to 9 marks this as the largest meeting ever held by the Society. Not in numbers alone did it surpass previous events, but in the size and variety of its program it was likewise notable. In the past it has been remarked that the Annual Meetings have taxed the capacity of the Engineering Societies Building. In the case of that of 1926 it may truthfully be said that at times the capacity of 39th Street between Fifth and Sixth Avenues was also taxed, as was plainly evident by the unusual congestion in that district and the extra traffic officers detailed there.

It would be almost impossible to name all the outstanding men in science, engineering, and industry who were drawn together by the fellowship of interest in mechanical engineering, and who profited by and enjoyed their contacts under such favorable circumstances. Many came as speakers at the technical sessions, others came to discuss the papers, and all came to learn and to make and renew friendships.



Charles M. Schwab — President, 1927
The American Society of Mechanical Engineers

The desirable "Contest of Keen Minds" was stimulated by the wide distribution of the papers to be presented at the meeting well ahead of the meeting date.

The discussions at the technical sessions were worthy of the papers and added much to their value. This amply justified the publication before the meeting of the Mid-November issue of MECHANICAL ENGINEERING containing most of the papers, and the preprinting of others in pamphlet form.

Aside from the major technical and social events of the meeting, there were held during the five days twenty-two technical sessions at which seventy-six papers were presented. More than fifty committee meetings were held, covering all phases of the Society's work—in many cases work which is not sensational as viewed by the public, but which eventually will have a profound effect upon engineering progress, upon industry, and therefore upon the public. Of such a nature is the work on Standardization.

There were nine excursions which were divided among outstanding power plants of the Metropolitan District, well-known machine companies, public-service plants, a great publishing plant, and a unique civil-engineering project. These excursions were conveniently handled by buses which came to the door of the Engineering Societies Building. They were well patronized, and in many cases served to illustrate and strengthen facts brought out in the technical sessions.

Parallel Events

Coincident with the A.S.M.E. Meeting three other events were going on in New York which did much to augment the value of the visit to the city at that time and which consequently received prominent notice in the Annual Meeting Program. The American Society of Refrigerating Engineers held its Twenty-Second Annual Meeting at the Hotel Astor, December 6–8, the Taylor Society held its Annual Meeting at the Engineering Societies Building, December 8–11, and the Fifth National Exposition of Power and Mechanical Engineering took place at the Grand Central Palace, December 6–11. On Tuesday, December 7, the A.S.M.E. held a joint session on heat transmission with the American Society of Refrigerating Engineers. On the same day the Taylor Society were guests of the A.S.M.E. Management Division in the morning, held a joint session with the A.S.M.E. Management Division in the afternoon, and in the evening coöperated with the A.S.M.E. Management Division and other organizations in an International Evening.

The Power Show occupied four floors in the Grand Central Palace, and not only were the latest developments in power-plant equipment exhibited, but there were also many examples of modern machine tools, standards, and other things related to the manufacture of power-plant equipment.

Presidential Address and Reception

The Presidential Address was one of the impressive events of the meeting. It took place on Tuesday evening, December 7, in the Engineering Auditorium before a large and brilliant audience. The address was delivered on this occasion by President William L. Abbott, who chose as his subject The Changing Relations Between Employer and Employee. President Abbott's address reflected throughout his thoughtful observations during his years of experience as an engineering executive in the power-plant field in Chicago. It likewise reflected the spirit of deep responsibility which he has felt during his year at the head of The American Society of Mechanical Engineers. This interesting address is published elsewhere in this issue.

One of the outstanding ceremonies of the 1926 President's Night was the presentation of the John Fritz Medal to Dr. Elmer Ambrose Sperry. The award was made by the John Fritz Medal Board, which is representative of the Four Founder Societies, in recognition of Dr. Sperry's development of the gyro compass and application of the gyroscope to the stabilization of ships and airplanes.

In his speech of presentation, William L. Saunders, Past-President of the American Institute of Mining and Metallurgical Engineers and Chairman of the Naval Consulting Board of the United States, reviewed the thirty years of Dr. Sperry's persistent efforts to harness the gyroscope for the benefit of mankind. Incidentally he revealed something of the aerial torpedo which Dr. Sperry had perfected just at the time the World War came to an end. The complete addresses will appear in the February issue.

Following this presentation, Claude Hartford, in behalf of the Board of Tellers, made public announcement of the results of the letter-ballot upon the officers and Council of the A.S.M.E. The following were declared elected:

President: CHARLES M. SCHWAB
Vice-Presidents: CHARLES L. NEWCOMB, EVERETT O. EASTWOOD, EDWARDS R. FISH
Managers: PAUL DOTY, RALPH E. FLANDERS, CONRAD N. LAUER

Delegates to the American Engineering Council: CHARLES M. SCHWAB, New York; O. P. HOOD, Washington, D. C.; DEAN E. FOSTER, Tulsa, Okla.; W. P. HUNT, Moline, Ill.; CHARLES PENROSE, Philadelphia, Pa.; E. N. TRUMP, Syracuse, N. Y.; THOMAS L. WILKINSON, Davenport, Ia.; D. ROBERT YARNALL, Philadelphia, Pa.; WALTER S. FINLAY, JR., New York, N. Y.; and IRA W. DYE, Seattle, Wash.

The final act in the ceremony in the Auditorium was the introduction of President-Elect Charles M. Schwab. Dr. William F. Durand, Past-President of the Society, presented him to the audience amid hearty applause.

Mr. Schwab responded in his genial manner, the keynote of his remarks—as was usual throughout the meeting—being the assurance of his sincere desire to promote the spirit of good-fellowship and coöperation within the Society and in its outside contacts. He described himself as far happier in the role of engineer than in that of financier. The scene of events then shifted to the fifth floor where there was a public reception to Mr. and Mrs. Abbott, Mr. and Mrs. Schwab, and Mr. and Mrs. Sperry. This was followed by dancing.

THE TOWNE AND THURSTON LECTURES

The presentation of the second Robert Henry Thurston and Henry Robinson Towne Lectures brought before the Society two leaders in the respective fields of science and economics. The Robert Henry Thurston Lecturer for 1926 was Dr. Cecil Howard Lander, of London.

Dr. Lander, who is widely known as a civil and mechanical engineer in England, is Director of Fuels Research, Department of Scientific and Industrial Research, in London. He spoke in a well-filled auditorium on Tuesday afternoon, December 7, upon Recent Discoveries in the Science of Coal Utilization, and described recent experiments and discoveries destined to be of great practical value to engineers. This paper is published as the leading article in this issue of MECHANICAL ENGINEERING.

The Henry Robinson Towne Lecture was presented to an equally large and appreciative audience in the Auditorium on Thursday afternoon, December 9. The lecturer was Dr. Davis R. Dewey, Professor of Economics and Statistics at the Massachusetts Institute of Technology, who for many years has been recognized as an authority upon these subjects. His paper was entitled The Credit Factor in the Structure of Industry, and it is also published in this issue of MECHANICAL ENGINEERING.

ANNUAL DINNER AT THE ASTOR

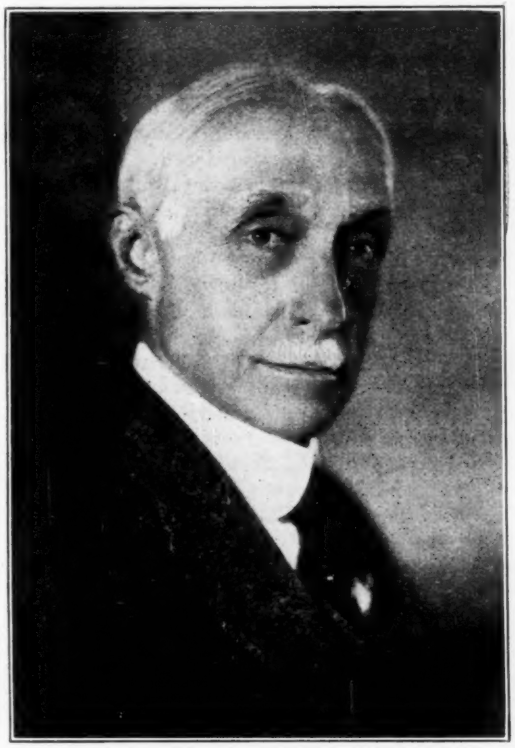
On the evening of Wednesday, December 8, a cheerful throng of 821 A.S.M.E. members and guests, including the ladies, gathered at the Hotel Astor for the main social event of the Society year—the Annual Dinner. This took place in the grand ballroom, the men being seated at tables on the main floor, while the ladies viewed the doings from the balcony.

President Abbott and President-Elect Schwab were seated with the toastmaster at a long table on a raised dais at the east side of the room. They were flanked by an unusual assemblage of honored guests, including presidents of sister societies, past-presidents of the A.S.M.E. and others who have taken a prominent part in its development—in several cases from its very beginning—and members of the Council. In front of this dais were seated the "35ers" many of them men of venerable appearance.

Roy V. Wright, the toastmaster, presided with ease and charm, and immediately spread the spirit of good feeling over the assemblage. Following the fine dinner President Abbott introduced the many notables at the speakers' table so that new members might know them. He called upon Secretary Rice to introduce the new members who have come in since the last Annual Meeting, each one standing as his name was called. It devolved upon Past-President Durand to deliver the charge to the new members, and this he did in a most impressive manner.

An unexpected event both to the general gathering and to the gentleman concerned was the presentation to Capt. Ralph Earle, President of Worcester Polytechnic Institute, of the John Scott Medal, Certificate, and Premium. This award was made by Dr. Louis Heiland on behalf of the Board of Directors of City Trusts of Philadelphia for his invention of Railway Naval Gun Mounts and the Mine Barrage, which played such an important part in the World War. In his response to the representative of the Board Captain Earle expressed his great surprise and also his deep appreciation of the honor accorded him.

President-Elect Schwab found no difficulty in holding the interest of the gathering as he eloquently unfolded to them his appreciation of his election, his intention of throwing the weight of his organizing experience into the work of the Society, and his hopes for the desirable outcome of his efforts at the end of his term. All this was interspersed with the interesting reminiscences and amusing stories for which the fluent industrial leader is famous. Incidentally he paid a graceful tribute to the good work of the Ladies' Auxiliary. There is no question but what, as usual, he thoroughly "sold himself" to his hearers. He impressed them not as a financier, but rather as a friend, a lover of humanity, and a sincere worker for the Society.



ELMER AMBROSE SPERRY—JOHN FRITZ MEDALIST FOR 1927

OTHER SOCIETY EVENTS

The Open House on Monday evening, December 6, introduced a spirit of friendliness at the very outset of the meeting which affected very favorably both the ladies and the gentlemen. The ladies, under the auspices of the Ladies' Auxiliary, which did splendid work throughout the meeting, gathered on the 11th floor of the Engineering Societies Building. Pleasant entertainment was provided, followed by refreshments. In the meantime the men gathered on the fifth floor where they listened to the reasons for a certain peculiar boiler explosion as set forth by certain self-styled and slightly prejudiced experts whose auxiliary equipment had not been installed. The strain of the trial was relieved by substantial refreshments which followed.

Other social events were the Ladies' Tea, Reception, and Dance at the Astor on Wednesday afternoon, and the college reunions on Thursday evening.

Excursions

There was no all-day excursion this year, mainly for the reason that the interest of the meeting was such that few people could afford to spend a full day away from headquarters. One of the unusual trips was that to the nearly completed Holland Vehicular Tunnel, which allowed a two-mile walk from New York to New Jersey under the waters of the Hudson. This took place on Thursday afternoon.

Other excursions included the Kip's Bay Station of the New York Steam Company, the East River Station of the New York Edison Company, the Hudson Avenue Station of the New York Edison Company, the plant of the American Machine and Foundry Company, the Harrison Gas Plant of the Public Service Company of New Jersey, the Hell Gate Station of the United Electric Light and Power Company, the De La Vergne Machine Company, the Diesel-Electric Ferry of the Erie Railroad, and the publishing plant of the New York *Evening Post*.

Council Meeting

Two meetings of the Council were held during the meeting. On Monday, December 6, with President Abbott in the chair, a large amount of routine business was dispatched.

On Friday, December 10, the new President, Charles M. Schwab, received his gavel and the newly elected members of the Council were introduced. Calvin W. Rice was reëlected Secretary. The following Executive Committee was chosen: President Charles M. Schwab, Past-President Fred R. Low, Past-President William L. Abbott, Past-President Dexter S. Kimball, Vice-President Roy V. Wright, Manager Conrad N. Lauer, The Council accepted the custody of three awards totalling $17,500 made by J. F. Lincoln for the best papers on arc welding. Following the action of the Business Session ratifying new amendments to the Constitution providing for the election of the Treasurer by the Council and the addition of a Vice-President, Erik Oberg of New York was chosen Treasurer and Harold V. Coes of Chicago, Chairman of the Finance Committee was chosen to fill the newly created office of Vice-President for the remainder of the Society year. Seattle, Wash., was selected as a meeting place for the Society during the late summer of 1927.

Local Sections' Delegates Conference

The functioning of the important Local Sections' Delegates Conference was particularly smooth this year, being marked by a much better arrangement of the delegates for the transaction of business and by a keener appreciation on the part of both delegates and committee of the problems under discussion. Representatives of nearly all of the sixty-eight Sections which make up the Society were present, and they met at 9:30 Monday morning for a conference which lasted throughout the day.

Prof. James A. Hall, chairman of the Committee on Local Sections, presided, and with him sat Col. Paul Doty, William A. Hanley, James D. Cunningham, Harry R. Westcott, and Ernest Hartford. The delegates were seated at double rows of tables surrounding the speakers' table on three sides in a sort of U-shaped formation.

The roll call was marked by brief reports of activities by the delegates. This was followed by short and inspirational addresses by men prominent in the national affairs of the Society. Among other things, an exposition was made of the work of the Professional Divisions and their important relation to the Local Sections. There was also some discussion of the Society's publications.

There was a recess at noon, at which time the delegates gathered at the Fraternity Club for luncheon with the Council of the A.S.M.E. President Abbott spoke at this luncheon. One of the lighter features was the presentation to Warren H. McBride, delegate from San Francisco, of a huge medal. This presentation was made by Dr. Ira N. Hollis in commemoration of Mr. McBride's accumulation of the greatest mileage in getting to the Annual Meeting, a record which he achieved by coming by way of the Panama Canal.

On Tuesday the work of the Local Sections Delegates continued, there being an independent conference of the representatives of the various Section Groups. The work concluded with a general business meeting.

Student Branch Conference

The work of cultivating the Student Branches in the realization that they represent the finest sort of material for the membership of the Society in the future, was continued during the meeting. A conference of delegates representing 35 of the 92 Student Branches was held Wednesday afternoon, December 8, with profitable results both for the delegates themselves and for the Committee on Relations with Colleges and the honorary chairmen, who are working in the interests of the prospective A.S.M.E. members.

On the same day the delegates of the Student Branches had lunch with President Abbott, President-Elect Schwab, and members of Council. They were privileged to hear at that time several highly inspirational talks, including one by Mr. Abbott and one by Mr. Schwab. It was an event which the young men are certain to remember long and pleasantly.

Business Meeting

The Annual Business Meeting of the Society was held on Wednesday afternoon, December 8, 1926, with President Abbott in the chair.

Claude Hartford, Chairman of the Tellers, reported that two amendments to the Constitution had been adopted by a letter ballot of the membership. The amendments voted on are as follows: the old wording deleted being shown in italics, while the added material is set in capitals:

ARTICLE C5, JUNIOR MEMBERSHIP

Sec. 6. A Junior must have had such engineering experience as will enable him to fill a subordinate position in engineering work, or he must be a graduate of an engineering school of accepted standing. He must be at least twenty-one (21) years of age, and his connection with the Society shall cease when he becomes *thirty (30)* THIRTY-FIVE (35) years of age unless he *be* HAS BEEN previously transferred to another grade.

ARTICLE C7, DIRECTORS AND OFFICERS (COUNCIL)

Sec. 1. No change.

Sec. 2. The Directors of the Society shall consist of a President *six (6)* SEVEN (7) Vice-Presidents, nine (9) Managers, AND the last five (5) surviving Past-Presidents *and a Treasurer.*

Sec. 3. No change.

Sec. 4. The President shall be elected for one (1) year, the Vice-Presidents for two (2) years, the Managers for three (3) years *and the Treasurer for one (1) year.*

Sec. 5. No change.

Sec. 6. (New Sec. 6 renumbering present Sec. 6 to Sec. 7.)

Sec. 6. AT ITS FIRST MEETING AFTER THE ANNUAL MEETING OF THE SOCIETY THE COUNCIL SHALL APPOINT A MEMBER OF THE SOCIETY TO SERVE AS TREASURER FOR ONE (1) YEAR.

THE TREASURER SHALL PERFORM THE DUTIES USUALLY PERTAINING TO HIS OFFICE, IN ACCORDANCE WITH THE BY-LAWS AND RULES, AND SUCH FURTHER DUTIES AS MAY BE REQUIRED BY THE COUNCIL.

ANY VACANCY IN THE OFFICE OF TREASURER SHALL BE FILLED BY APPOINTMENT BY THE COUNCIL.

Sec. 7. (Same as old Sec. 6.)

The Nominating Committee of the Society for 1927, as selected by the Conference on Local Sections Delegates, was presented by H. R. Westcott representing the Standing Committee on Local Sections. The Committee as elected consists of the following members:

Group I—Frank M. Gunby, Boston. Saml. D. Fitzsimmons, Providence, *Alternate.*

Group II—James Partington, New York. H. H. Barnes, Jr., New York, *Alternate.*

Group III—V. L. Sanderson, Philadelphia. Charles Schenck, Lehigh Valley Section, *Alternate.*

Group IV—E. J. Fermier, Houston. Chas. E. Ferris, Knoxville, *Alternate.*

Group V—Morgan B. Smith, Detroit. John T. Faig, Cincinnati, *Alternate.*

Group VI—Walter C. Linderman, Milwaukee. Wilson P. Hunt, Tri-Cities Section, *Alternate.*

Group VII—William Lester, Colorado. A. LeRoy Taylor, Utah, *Alternate.*

The group number refers to the group of local sections which selected individual members of the Committee. At a subsequent meeting of the Committee, Frank M. Gunby was chosen Chairman and Morgan B. Smith, Secretary.

One of the important features of this Session was the award of the Charles T. Main Prize and the Student Prizes. The winners were presented by Dr. Ira N. Hollis, Chairman of the Awards Committee, and the prizes were bestowed by the President. The following were honored by Student Prizes: Cecil G. Heard for his paper on Pressure Distribution Over a U.S.A.-27 Aerofoil with Square Wing Tips—Model Tests, and R. E. Peterson for his paper on An Investigation of Stress Concentration by Means of Plaster of Paris Specimens. The Charles T. Main Award was given to W. C. Saylor for the best paper on the Effect of the Cotton Gin upon the Politics of the United States from 1787 to 1857.

Other routine business included the presentation of the Annual Report of the Council by Secretary Rice and the reading of the following Standards by title: Cast-Iron Pipe Flanges and Flanged Fittings for 125 Lb. per Sq. In.; Cast-Iron Pipe Flanges and Flanged Fittings for 250 Lb. per Sq. In.; Malleable-Cast-Iron Screwed Fittings for 150 Lb. per Sq. In.; Cast-Iron Screwed Fittings for 125 and 250 Lb. per Sq. In.

Other Features of the Meeting

The work of the fourteen Professional Divisions received attention on several occasions during the meeting. One of these occasions was a dinner at the Fraternity Club of the Council and the Chairmen of the Professional Divisions. At this time the year's activities of the Divisions were presented in a graphical form which made clear comparisons possible and which brought out the points of weakness as well as the points of strength. President Abbott spoke upon the possibilities open to the Divisions. Robert T. Kent, Chairman of the Standing Committee on Professional Divisions, made use of this opportunity to praise some Divisions for worthy accomplishments and to spur others into more vigorous action. Each of the Division representatives present was called upon to give a brief report on the plans that had been laid out for the coming year.

The progress reports of the Professional Divisions were this year individually presented at technical sessions representative of each Division's work instead of being presented *en masse* at the Business Meeting as was the case last year. They were read by the Division chairmen and were of real interest and value. They showed that they were based upon a year of close observation and careful thought on the part of those who prepared them, and not only told of marked advances in mechanical engineering but also indicated that in many cases the Divisions of the A.S.M.E. have encouraged and participated in this progress.

Technical Sessions at Annual Meeting

Session on Industrial Power

THE Session on Industrial Power was held on Tuesday morning, December 7, Prof. A. G. Christie, Vice-President of the Society, presiding. The first paper presented, entitled Properties of Boiler Tubing at Elevated Temperatures Determined by Expansion Tests, by A. E. White and C. L. Clark, gave the preliminary findings of an investigation on 0.13 carbon-steel seamless tubing when loaded at temperatures ranging from 900 to 1500 deg. fahr. In boiler tests there is a growing tendency to increase both temperature and pressure, and but little is known of the properties of steels at elevated temperatures, particularly when the latter are maintained for long periods of time. One of the most significant features of the test, the authors stated, was that for temperatures of 1500 and 1250 deg. fahr., at least, the proportional limit as ordinarily determined was found not to be the criterion of stability. The paper was discussed in writing by H. T. French, and orally by J. M. Lessells, J. C. McCabe, G. B. Karelitz, and W. H. Jacobi.

In the second paper, on the Relation of Stokers to Boilers, W. A. Shoudy, the author, presented data to show that the selection of the correct combination of stoker and boiler could not be determined by rule-of-thumb methods, nor could it be based on comparisons of operation in certain percentages of rating. He pointed out the steps in the development of stokers and the effect on efficiency, and discussed the difficulties incurred at high rating and remedies therefor, as well as the successive steps which must be taken in the selection of the correct combination of stoker and boiler.

Written discussions of Mr. Shoudy's paper were contributed by W. H. Jacobi, Howard E. Bacon, and J. S. Bennett, 3rd, while David Moffat Myers, N. E. Funk, C. G. Spencer, A. A. Cary, Hosea Webster, and R. S. Baynton commented orally thereon.

The third paper presented, entitled Power-Station Accounting for Industrial Plants, by W. R. Herod, gave particulars of a system of procedure that had been employed satisfactorily with but minor modifications for over three years in a group of seven factory plants. Mr. Herod's paper appeared in the Mid-November, 1926, issue of Mechanical Engineering.

Guy B. Randall submitted a written discussion, while those speaking from the floor included M. K. Bryan, R. A. Packard, W. Viessmann, C. H. Bigelow, H. M. Burke, and W. A. Shoudy.

Wood Industries Session

RALPH E. FLANDERS, Chairman of the Publication Committee and Council member-elect of the A.S.M.E., presided at the Session on Wood Industries held under the auspices of the Wood Industries Division on Tuesday morning, December 7.

The papers presented were: Wood Finishing—A Glance Ahead, by F. L. Browne; The Technology of Wood Stains and Fillers for Use with Lacquer, by S. M. Silverstein; The Use of Wood Lacquer Finishes, by Walter S. Edgar; A Study of Varnish and Lacquer Finishes Exposed to Accelerated Breakdown Tests, by Paul S. Kennedy; and Safety Code for Wood Working Plants, by E. Ross Farra. The Progress Report of the Wood Industries Division was read at the close of the session by Paul H. Bilhuber.

In discussing Mr. Browne's paper Carl L. Bausch of the Bausch & Lamb Optical Co., Rochester, N. Y., called attention to the possibilities of the microscope in measuring the thickness of transparent varnish or lacquer coatings. This, he said, could be accomplished by focusing, under a strong vertical light, first upon the surface of the finish and then upon the surface of the wood, the thickness being read from a graduated adjustment button.

Thomas D. Perry cited the difficulty which even experienced workmen now have in detecting the difference between cheap and expensive finishes by simple inspection. He made a plea for better gages for the value of finishes.

Mr. Perry made a similar plea following the presentation of Mr. Edgar's paper, and Mr. Edgar called attention to the work now being done by the Lacquer Committee of the American Society for Testing Materials. Mr. Edgar was able to answer many questions which the reading of his paper aroused. There was also some discussion as to the effect of mixing animal, vegetable, and mineral substances in fillers and finishes. This developed into a discussion of the matter of expansion and contraction. Mr. Silverstein contended that rather than try to educate the public to care for frail finishes, the goods themselves should be made more stable by treating the wood against reasonable fluctuations due to atmospheric changes. This, Mr. Silverstein said, was now entirely possible of accomplishment.

The reading of Mr. Kennedy's paper aroused an interesting discussion of the value of the Cooper Hewitt lamp as a medium for artificially aging wood finishes. Mr. Thompson, of Meriden, Conn. contended that this lamp falls short of direct sunlight in its effect, and that furthermore its spectrum loses some of its powerful ultraviolet rays after being in use for a short time.

Mr. Silverstein replied that when the Cooper Hewitt lamp says "No" it saves further waste of time. If it says "Yes," the finish should be still further tested by direct sunlight.

Mr. Hopkins told of his satisfactory experiences with the Cooper Hewitt lamp in conjunction with ozone for rapid aging tests. He stated that the New Jersey Zinc Company has found that the lower wave lengths may be maintained after the first 1200 hours by boosting the voltage. They test their lamps every four or five hours for spectrum quality.

Session on Textiles

A SESSION on Textiles was held on the morning of December 7, under the auspices of the Textile Division. James A. Campbell, Chairman of the Division, presided.

Before the presentation of the papers, C. W. Price delivered a five-minute talk on safety. Mr. Price brought out four facts of interest: namely, that statistics for 1923 compared with those of 1919 showed an increase of 27 per cent in accidents causing loss of time in industry; that figures for 1925 are expected to show an increase of 30 per cent over 1919; that these conditions are the result of the employer not being informed; and that it has been demonstrated that 75 per cent of accidents can be prevented.

The first paper on the program was one by Charles T. Main and Frank M. Gunby, entitled The Cotton Textile Industry. This paper had been presented at the Old Dominion Meeting of the A.S.M.E. in Richmond, Va., September 27–30, 1926, and was published in the October, 1926, issue of MECHANICAL ENGINEERING, but owing to the importance of the subject treated, it was considered advisable to present it again at this session. Among those taking part in the discussion were: Chairman Campbell, Frank W. Van Ness, H. M. Burke, Charles T. Plunkett, and McRae Parker. An account of the discussion, which emphasized the comparative economic conditions of the North and the South, will appear in an early issue of MECHANICAL ENGINEERING, together with the authors' closure.

The second paper, Tensile Testing of Textiles, was presented by Dr. W. F. Edwards. It dealt with the development of testing methods from the days of hand testing (merely pulling the yarns by hand until they broke) down to the present tendency toward more accurate results through the use of recording testing machines. The possible trend of future development was also mentioned. The paper was discussed briefly by J. W. Cox, H. T. Scott, and David Scott. Dr. Edwards replied to several questions raised and will treat each fully in the published account of the discussion, which will shortly appear in MECHANICAL ENGINEERING.

Chairman Campbell read the Progress Report of the Textile Division before closing the session, and mentioned the fact that the Cotton Textile Institute has offered its services to the Division.

Session on Smoke Abatement

THE Session on Smoke Abatement, under the auspices of the Fuels Division, was held on the afternoon of December 7, 1926, with the Chairman of the Division, O. P. Hood presiding.

Three papers were presented at this session, as follows: Smoke Abatement, Its Effect and Its Limitations, by H. B. Meller; What is Known about the Effect of Smoke on Health, by W. C. White; and Present Status of the Smoke Problem, by Osborn Monnett.

In the absence of the author, Mr. Meller's paper was presented in abstract form by Prof. C. De Zafra. The paper showed the benefits of smoke abatement as carried on in a number of cities, and discussed the methods used to obtain the desired results. The effects of the solid particles and fumes upon health were mentioned, and an appeal for a thorough study of the entire problem of air pollution was made. The paper was discussed in writing by Dr. A. A. Bato, H. W. Clark, J. D. Riggs, Dr. C. J. Vaux, Dr. E. R. Weidlein, and John Barkley. Those offering oral discussion were E. J. Kunze, John Hunter, and the chairman.

Dr. White presented his paper in abstract form, dealing briefly with visible pollution of the air, early attempts to regulate smoke, a proposed plan for further investigation, and the physiological effect of carbon particles and other dusts in smoke. No written discussion was submitted, but Dr. Jerome Meyers, Prof. A. R. Acheson, and the chairman offered remarks from the floor, with the author replying to questions and further elaborating on his subject.

Mr. Monnett's paper dealt with progress in the solution of the smoke-abatement problem, the problem of the small plant and the human element especially being discussed. The paper appeared in full in the Mid-November, 1926, issue of MECHANICAL ENGINEERING. Written discussions were presented by H. W. Clark, Prof. A. G. Christie, T. B. J. Merkt, W. G. Christie, and V. J. Azbe. The discussion was continued orally, with the following participating: W. G. Christie, Warren Viessman, McRae Parker, Colonel E. H. Whitlock, Dr. A. A. Bato, Morgan Smith, E. J. Kunze and the chairman.

A more detailed report of the two unpublished papers, together with the discussion of all the papers, will appear in a later issue of MECHANICAL ENGINEERING.

Annual Meeting Committees

Committee on Meetings and Program

C. N. LAUER, *Chairman*
E. HOWARD REED
R. M. GATES
S. W. DUDLEY
W. L. BATT

Staff Representatives

GUY HUBBARD
R. D. MORRILL
G. A. STETSON
W. F. TURNBULL
C. DE ZAFRA

Sub-Committees for 1926 Annual Meeting

EMMETT B. CARTER, *General Chairman*
F. M. VAN DEVENTER, *Vice-Chairman*

Reception
J. W. COX, JR., *Chairman*
J. O. G. GIBBONS
C. H. BERRY

Courtesy
A. W. LENDEROTH, *Chairman*
ROSWELL MILLER
E. B. MEYER

Open House
A. A. ADLER, *Chairman*
J. E. STRAIN
M. P. ROBINSON
EDW. B. RICKETTS

Catering
W. M. KEENAN, *Chairman*
A. R. MUMFORD
A. C. TOWNSEND

Presidents' Night
JOHN PRICE JACKSON, *Chairman*
S. H. LIBBY
WILLARD BRINTON
WM. B. JACKSON
H. BIRCHARD TAYLOR

Information
ERNEST BRAMBLE, *Chairman*
N. F. FRIGIOLA
J. F. DAGGETT
E. B. BERGER

Excursions
R. A. WRIGHT, *Chairman*
R. G. ADAMS
H. D. SAVAGE
E. E. JACKSON

Dinner
JOS. W. ROE, *Chairman*
FREDERICK A. SCHEFFLER
G. L. KNIGHT
CLAUDE HARTFORD
FRED R. LOW
JOHN H. LAWRENCE
CONRAD N. LAUER
CLARKE FREEMAN
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Ladies' Committees
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MRS. L. R. GURLEY, *Chairman Registration*
MRS. CARL WRIGHT, *Chairman Excursions*
MRS. FRANK T. CHAPMAN, *Chairman Decorations*
MRS. ERIK OBERG, *Chairman "Get-Together"*
MRS. M. S. CUMNER, *Chairman Luncheon*
MRS. W. C. BRINTON, *Chairman of Hostesses for Presidents' Night*
MRS. A. N. BENNETT, *Chairman Tea and Dance*
MRS. J. W. ROE, *Chairman Woman's Hospitality*
MRS. CALVIN W. RICE, *Chairman Theater*

Railroad Session

THE Railroad Session, held under the auspices of the Railroad Division, convened at 2:00 p.m., December 7, with William Elmer, Member of Executive Committee, Railroad Division, presiding.

Before the presentation of the papers, Col. John Price Jackson delivered a five-minute talk on safety. Following this talk H. B. Oatley reported the death of Prof. John M. Snodgrass, one of the authors of the first paper on the program, on December 5. A

resolution on his death, presented by Mr. Oatley, was unanimously adopted by a rising vote.

The paper on The Use of High-Steam Pressure in Locomotives, by E. C. Schmidt and J. M. Snodgrass, was presented by Professor Schmidt. This paper, which summarized the advantages of using high-steam pressures in reciprocating locomotives and reviewed the more notable applications of steam pressures of 240 lb. per sq. in. or higher, appeared in the Mid-November, 1926, issue of MECHANICAL ENGINEERING. Considerable written discussion followed, those contributing being L. H. Fry, A. I. Lipetz, James M. Taggart, W. F. M. Goss, R. Eksergian, V. L. Jones, Harold Anderson, Charles B. Page, A. H. Fetters, and W. A. Newman. Owing to the great amount of information contained in these discussions, no attempt will be made to give even a brief abstract in the space available at this time. However, a full account together with the authors' closure will appear in an early issue of MECHANICAL ENGINEERING.

L. K. Sillcox presented a paper on Balancing Factors in the Use and Obligations Covering Ownership of Freight-Train Cars, in which the problems of terminals, slow movement of freight trains, intensive use of cars, maintenance, depreciation, retirement factors, and design were discussed. Numerous slides added to the value of the paper. A rather lengthy written discussion was presented by W. E. Symons, who emphasized the great importance of cordial coöperation in the solution of the problem. He also discussed depreciation as a factor of operating economy, and mentioned the increased efficiency of railroads, the change in their relations with the public, and the splendid work of public-relations bodies. He considered the misuse and abuse of freight cars a deplorable condition demanding immediate attention.

The Report of the Committee on Professional Service, prepared by Marion B. Richardson, Chairman, and read by R. S. McConnell, was received most favorably. It will be published in full in an early issue of MECHANICAL ENGINEERING.

Last on the order of business was the presentation of the Progress Report of The Railroad Division. This report, which was published in the December, 1926, issue of MECHANICAL ENGINEERING under the title Progress in Railroad Mechanical Engineering, was presented by the Chairman of the Division, H. B. Oatley. C. F. Street commented briefly on the report, emphasizing the importance of understanding the relative importance of things.

Session on Heat Transmission

THE Session on Heat Transmission was held jointly with the A.S.R.E., on Tuesday afternoon, December 7, the program being arranged by the Committee on Heat Transmission of the National Research Council.

W. H. Carrier, Chairman of the above-mentioned Committee, presided, and Prof. Comfort A. Adams outlined its scope and program. The heat-transmission problem, he said, was one of the branches of engineering which had failed to receive the recognition which its great importance warranted. There was a tremendous amount of data available resulting from experiments made in the laboratories of various corporations and institutions and covering small parts of the field, many of them overlapping. These data, however, were uncoördinated, and whenever one found it necessary to obtain fundamental data that would serve as the basis of calculations in certain problems, he was compelled to waste an unbelievable amount of time in digging it out. Professor Adams had made a rough estimate of the probable waste of fuel due to the guesswork sometimes called calculation, involved in the designing of heating systems in buildings, and felt safe in saying that in this country millions of tons of fuel were unnecessarily wasted every year because of the lack of exact information. The importance of coöperation, avoiding duplications, overlapping of standardizing nomenclature, and filling up the gaps in our knowledge of the subject was therefore unquestioned.

The movement, Professor Adams continued, had been organized some years ago under the auspices of the National Research Council, and its work was being done by four major groups, one of them dealing with definitions, nomenclature, and symbols; another with the measurement of heat transmission; a third with the heat transmission of insulating and building materials; and the fourth group with heat transmission between metals and fluids.

Thirteen papers were presented at this session and elicited a considerable number of written discussions. Four of the papers were published in advance in the Mid-November, 1926, issue of MECHANICAL ENGINEERING, and several others were available in pamphlet form at the meeting. The Chairman stated that later all of the papers would be brought together in one volume and printed jointly by the A.S.M.E. and the A.S.R.E. so that they would be available in one group.

First General Session

THE first General Session was held Tuesday afternoon, December 7, with Prof. Robert W. Angus, Vice-President, A.S.M.E., presiding.

The papers presented were: Measurement of Static Pressure, by Carl J. Fechheimer; The Emergency Stops of the Gearless Traction Elevator at the Terminal Landings, by F. Hymans; A Mercury Compressor Evolved from the Archimedes Screw Pump, by J. G. DeRemer; and The Lubrication of Waste-Packed Bearings, by G. B. Karelitz. An interesting safety talk was given during the meeting by Samuel H. Libby, in which he illustrated some of his points by personal recollections of a small foundry of forty years ago.

Mr. Fechheimer's paper was discussed by H. L. Dryden, Frank W. Caldwell, E. M. Fales, J. M. Spitzglass, and S. A. Moss. The discussion centered mainly upon the Fechheimer tube, its modifications and its further possibilities.

Mr. Hymans' paper was a long one and was necessarily briefly abstracted when presented. This was done, however, in a way which brought out the main points clearly well within the time allowed. The paper was confined to thorough investigations of the oil buffer and the limit switch in elevator practice. No discussion was presented.

Mr. DeRemer's paper was illustrated by the use of one of the actual machines, the vital parts of which had been sectioned to show the interior. This paper, which appeared in the Mid-November issue of MECHANICAL ENGINEERING, aroused keen interest before and during the meeting and brought forth interesting comments. Discussions were presented by E. A. Sperry, A. R. Stevenson, Jr., T. B. J. Merkt, A. M. Hunt, C. P. Benns, F. N. Connet, and L. A. Phillip. In his closure Mr. DeRemer was able to answer several interesting questions which were brought up during the discussion. He mentioned that some one had called his attention to the fact that as the descendant of the Archimedes spiral his machine should be manufactured in Syracuse instead of in Ithaca (N. Y.)!

Mr. Karelitz' paper told of a very complete series of experiments upon a common type of industrial bearing, and drew conclusions of much interest to practical designers. These covered types of waste and lubricants, design of reservoirs, and location and action of oil grooves. Discussion of this paper was confined to A. F. Brewer, who dealt with lubricating questions.

Session on By-Product Processing of Coal

THE session on By-Product Processing of Coal, held on the morning of Wednesday, December 8, may be broadly divided into two parts, that dealing with low-temperature carbonization, and that dealing with complete gasification of bituminous coal. The papers by A. C. Fieldner and Wm. H. Blauvelt belong to the first, while that of R. S. McBride belongs to the second. In the former there was a noticeable cleavage between the views of the authors of the papers and those of discussers, the latter being frankly free of the hopeful optimism of the former. In fact, one gathered from the discussion the impression that if any of the discussers felt any sympathy for or hope in low-temperature carbonization, they certainly did not express it. H. W. Brooks, Consulting Engineer of the Fuller-Lehigh Co., Fullerton, Pa., presided over the session.

A short talk on the importance of accident prevention and safety was given by D. J. Price of the National Safety Council, which was followed by a few remarks by the Chairman on the early days of coal carbonization and the paper by Arnold C. Fieldner, Super-

intendent of the Pittsburgh Experiment Station, U. S. Bureau of Mines. This was followed by the paper by Wm. H. Blauvelt, Consulting Engineer, of New York City. In the discussion of Mr. Blauvelt's paper, J. A. Perry told about the most recent improvements in the high-temperature distillation of coal, with the implication that low-temperature distillation has no chance in the face of such powerful competition as the high-temperature distillation is likely to present within the next few years.

Prof. A. G. Christie pointed out the economic limitations of smokeless fuel, both in domestic heating and as a central-station fuel. What is most needed at the present time is a clearer appreciation by all concerned of certain fundamentals in the treatment of coal by low-temperature processes, and these are still only vaguely known.

G. E. Rohmer told about the application of some German discoveries in an experimental plant in America. This was followed by a talk by Geo. A. Orrok, who emphasized the economic side of the problem, in particular the lack of a market for nitrogenous products of distillation. He also expressed doubts as to the fuel efficiency of the products of low-temperature processing of coal.

Following Mr. McBride's paper on the Complete Gasification of Bituminous Coal, discussions were presented by J. A. Perry and F. C. Weber. Both discussers warmly supported Mr. McBride's views, except that Mr. Weber expressed doubts as to the cost of distribution of low-heat-value gas.

The Report of the Fuels Division on Progress in Fuel Engineering, prepared by G. E. Lesher, a member of the Fuel Division, was presented by Prof. E. C. Schmidt of the University of Illinois, Chairman of the Division, and this was followed by brief concluding remarks by the authors of the papers.

Machine-Shop Practice—First Session

THE first session on Machine-Shop Practice was held on Wednesday morning, December 8, under the auspices of the Machine-Shop Practice Division and the Research Sub-Committee on Cutting and Forming of Metals. Prof. James A. Hall, Chairman of the committee just mentioned, presided at this meeting.

Three papers were presented, these being: A Research in the Elements of Metal Cutting, by O. W. Boston; Rough Turning with Particular Reference to the Steel Cut, by H. J. French and T. G. Digges; and Work-Hardening Properties of Metals, by Edward G. Herbert.

Professor Boston's paper told of a costly and unique series of experiments upon planing cuts which was carried on at the University of Michigan under his direction. He drew many interesting conclusions from this long series of experiments, and the abstract of his paper as presented at the session with slides touched upon the major points.

H. J. French presented the paper prepared by himself and Mr. Digges in a clear abstract form which brought out the main points very well. This covered experimental work of a practically useful nature which in a manner supplements that of the late Frederick W. Taylor.

Edward G. Herbert's paper was read by Joseph K. Wood, who is familiar with the work carried on by Mr. Herbert in Manchester, England.

When Professor Hall threw the session open for group discussion of the papers the response was very satisfactory, and a number of the discussers offered comments on all of the papers. Among the discussers were: H. W. Graham, R. Poliakoff, Carl G. Barth, T. H. Wickenden, R. S. Sterns, R. S. Discell, A. L. De Leeuw, and A. L. Davis.

Both Mr. De Leeuw and Mr. Barth had had extended experience along the lines of research followed by Messrs. Boston, French, and Digges, and were able to contribute much from their personally acquired knowledge. Mr. Barth's remarks were concentrated upon the subject of special slide rules designed for machine-shop use, and Mr. De Leeuw mentioned his discoveries in the use of cutting tools with extreme shear angles and with polished tops. Both papers and discussions emphasized the amount of research work which is now being done toward the end of raising machine-shop technique from the realm of empiricism to the realm of true engineering.

Session on Materials Handling

THE Session on Materials Handling was held on the morning of December 8. James A. Shepard, Chairman of the Materials Handling Division, presided.

Before presentation of the papers, a five-minute safety talk was delivered by G. C. Agry. Mr. Agry referred to the impetus given the safety movement by the recent meeting of the National Safety Council in Detroit. He also showed the desirability of considering the four factors of modern materials handling: namely, speeding production, saving in handling labor, reduction in floor-space requirements, and reduction in cost of manufacture; and directed his arguments toward tying them up with safety.

The papers presented at this session were Industry's Annual Tax for Materials Handling and Suggestions for Its Elimination, by Harold V. Coes, and The Industrial Applications of Conveyor Systems, by C. A. Burton.

Mr. Coes discussed the reduction of the national materials-handling bill a billion dollars a year by utilizing equipment now available, relocation of stock rooms, and the proper coördination of production with equipment for moving materials. The paper was not presented in full, as it appeared in the Mid-November, 1926, issue of MECHANICAL ENGINEERING, where members had an opportunity to read it. No written discussions were presented, but the following participated in the oral discussion: V. N. Tobin, Max Sklovsky, P. H. Nydegger, Charles H. Bigelow, and J. C. Gillett. Owing to the length of the discussion and the matter presented, it is impossible to review it at this time, but an account in some detail may be expected in MECHANICAL ENGINEERING in an early issue.

Mr. Burton's paper discussed four utility factors of raw materials for manufacturing, namely, substance, form, place, and time, and two general types of conveying machinery, illustrating the theories mentioned by concrete examples. As an example of an industry lately receiving the attention of the mechanical engineer, he cited the modern laundry, describing the steps necessary to carry the clothes from the receiving department to the delivery. The following offered comment in the oral discussion: Max Sklovsky, McRae Parker, Spencer Miller, and the Chairman.

Prof. J. W. Roe also commented on the general subject of materials handling with particular reference to the materials-handling formula as worked out in Mr. Coes' paper. The Chairman also entered this discussion with considerable vigor. Additional remarks were offered by Mr. Coes and Mr. Agry.

The Progress Report of the Materials-Handling Division was presented by the Chairman, who called attention to the fact that it appeared in the December, 1926, issue of MECHANICAL ENGINEERING. Comments from the floor were offered by Alfred Vaksdal and F. E. Blake.

Second General Session

THE second General Session convened at 9:30 Wednesday morning, December 8, with Prof. L. S. Marks in the chair.

After a few brief introductory remarks by the Chairman the paper on Tests and Theory of Curved Beams by A. M. Winslow and R. H. G. Edmonds was presented. In this paper the authors discussed strain-gage observations at several points throughout cross-sections of large steel specimens, determining complete strain curves. In a written discussion of the paper, Casper D. Meals mentioned the work of Professor Andrews in which it is shown that there is very little difference in the results between the Winkler and Andrews-Pearson theories. The theory of Bach also was discussed at considerable length. S. Timoshenko, in writing, presented what he termed an exact solution of the problem of curved bars of rectangular section, obtained in 1880 by Prof. H. Golovin. A later solution of the same problem by Prof. L. Prandtl also was mentioned. Further written discussion by Dirk Dekker pointed out the close agreement of the analytical results with the experimental. A rather lengthy discussion was submitted by F. N. Menefee in writing, in which he enumerated some of the points often omitted by engineers, submitted methods of analysis, and commended the work of the authors. Oral discussion was offered by A. L. Kimball, Dr. Timoshenko, and the chairman,

with Professor Winslow, who presented the paper, replying to questions raised.

The paper by A. L. Kimball and D. E. Lovell, on Internal Friction in Solids, was next presented by Mr. Kimball in abstract. The paper contained a description of the apparatus used in the investigation and a tabulation of the results obtained. Equations relating variables involved were derived. Written discussions were offered by B. B. Kommers, H. F. Moore and N. P. Inglis, and T. McLean Jasper. Mr. Kommers referred to other papers describing test apparatus similar to that used by the authors. He drew a word picture of the happenings in a rotating specimen. Messrs. Moore and Inglis mentioned the work of Mason on mechanical hysteresis. A curve showing values of the lateral deflection test was submitted. Mr. Jasper commented on the relation of the subject to rate of stress propagation, internal stress relief and to the general gyroscopic action of bodies under bending stresses. Dr. Timoshenko and the Chairman commented orally on the paper, to which Mr. Kimball replied at some length.

William M. Frame presented a paper on Stresses Occurring in the Walls of an Elliptical Tank Subjected to Low Internal Pressures, describing tests on an actual tank and making an analysis based on the experimental data, from which the stresses in the walls may be calculated. No written discussion was offered, but Dr. Timoshenko commented orally on several points.

The final paper in this session was by M. Stone and dealt with Stresses and Deflections in Large Dynamo Frames Due to Dead Load. The results of a series of investigations by the Westinghouse Electric and Manufacturing Company were given, together with tables and equations for use in designing machines much lighter than those now in use. Written discussions were offered by R. Eksergian, William Hovgaard, and C. A. Norman. Mr. Eksergian mentioned methods of attack through the analysis of elastic structures. Mr. Hovgaard also discussed the points of attack. The great saving in machine-shop labor and materials resulting from the solution of the problems mentioned was pointed out by Professor Norman. Further comments were offered orally by Dr. Timoshenko, F. A. Haughton, and Mr. Stone.

Education and Training for the Industries of the Non-College Type

ON WEDNESDAY afternoon, December 8, a session was held in the Auditorium covering various phases of industrial training. This session was under the auspices of the Committee on Education and Training for the Industries and was presided over by R. L. Sackett, a member of this committee.

The meeting was preceded, as in several other cases, by a safety talk delivered by L. A. DeBlois, past-president of the National Safety Council.

The opening address was given by President W. L. Abbott, who presented some interesting viewpoints upon training methods, old and new. He stressed the fact that it has been demonstrated of late that skilled workmen can be developed much more rapidly than was the case under the old-fashioned apprenticeship systems. He predicted that it would not be long before training schools within the industries and under the direction of specialists would begin to meet the heavy demands for craftsmen.

The subjects covered at this session were Trades Training, by Carl S. Coler, and Educational Training for Industry, by Matthew Woll. Both of these papers were published in the Mid-November issue of MECHANICAL ENGINEERING and provoked considerable discussion, both spontaneous and prepared.

Discussions of Mr. Coler's paper were presented by J. H. Bigelow, J. E. Goss, A. E. Holstedt, J. C. Parker, and W. E. Wickenden. These discussions were, in the main, in a spirit of admiration of Mr. Coler's contribution. They brought up several questions which Mr. Coler answered in his closure, thereby augmenting the value of his original presentation.

Discussion of Mr. Woll's paper was of a considerably more critical nature. Those who contributed to it were: Luther D. Burlingame, Ernest F. DuBrul, John T. Faig, and Robert Newcomb. The general tenor of their remarks was that while many of Mr. Woll's statements pictured very desirable conditions, they were not conditions which actually existed. They called attention to specific instances where the policies of the unions seemed to hinder rather than help, and urged that such conditions be remedied for the general good of the industries concerned.

Professor Faig, without direct reference to either paper, confined his remarks rather to calling attention to the valuable collection of papers on education and training which have appeared in MECHANICAL ENGINEERING in the last two years. He mentioned fourteen such papers, most of which have been prepared at the instance of the Committee on Education and Training for the Industries.

Steam Tables Research

DR. D. S. JACOBUS presided at the Session on Steam Tables Research, which convened at 3:00 p.m., December 8.

First on the program was the report of the Executive Committee of the Steam Tables Fund. This was presented by George A. Orrok, who discussed the financing and progress of the work, with particular reference to the activities at the Massachusetts Institute of Technology under Dr. F. G. Keyes. He also mentioned diagrams developed two years ago to show variations between values of various authorities. Papers by Dr. Callendar and H. L. Guy were mentioned in this connection.

Following this report, the chairman asked for reports as to the status of the investigations.

Dr. L. B. Smith reported on the progress of the work at the Massachusetts Institute of Technology, mentioning some of the difficulties encountered in the measuring instruments, and the manner in which they were overcome. Dr. F. G. Keyes, of the Research Laboratory of the Massachusetts Institute of Technology, also touched upon the work at the Institute, especially with reference to the measurement of pressures. Some discussion prevailed at this point, C. H. Berry, Chairman Jacobus, Dr. H. N. Davis, E. F. Mueller, and A. D. Risteen participating.

Dr. E. F. Mueller reported on the work of the Bureau of Standards on the specific heat of water. He mentioned the difficulties encountered in the early stages of the work, and described some of the instruments built for the tests.

Dr. H. N. Davis touched upon the writings of Dr. Callendar. He also discussed the tables prepared by Keenan. Others entering into the discussion of the progress in this field were: Prof. R. C. H. Heck, A. D. Risteen, Dr. Davis, Prof. L. S. Marks, Prof. F. O. Ellenwood, Prof. M. C. Stewart, Dr. Mueller, and the Chairman.

Session on Central-Station Power

THE Session on Central-Station Power was held on Thursday morning, December 9, C. H. Berry, presiding. Following the presentation by H. B. Reynolds of the report of the Power Division on Progress in Steam Power Engineering, five papers were read, namely, Operating Performance of Modern Surface Condensers, by Paul Bancel; Some Results of Condenser Operation, by E. B. Ricketts; Steam-Condenser Practice and Performance, by F. J. Chatel; The Influence of Radiation in Coal-Fired Furnaces on Boiler-Surface Requirements and a Simplified Method for Its Calculation, by W. J. Wohlenberg and E. L. Lindseth; and Accuracy of the V-Notch-Weir Method of Measurement, by D. Robert Yarnall.

Mr. Bancel's paper, which will appear in a later issue together with the discussion, gave operation records of modern surface condensers showing efficiencies obtained from fundamental improvements in design. The paper was discussed in writing by G. L. Kothny and P. E. Reynolds.

Mr. Ricketts' paper, which appeared in the Mid-November, 1926, issue of MECHANICAL ENGINEERING, page 1312, gave results of about fifty tests made at weekly intervals during 1925 and 1926 on four condensers for the purpose of aiding the operation of the apparatus under consideration. Written discussions on this paper were submitted by Theodore Baumeister, H. T. Thielsher, G. L. Kothny, and D. W. R. Morgan.

Mr. Chatel's paper gave particulars regarding steam-condenser practice and performance in the four plants of the Detroit Edison Company. C. D. Zimmerman contributed a written discussion and D. W. R. Morgan commented orally on the paper. This

paper, together with the discussion, will appear in a later issue of Mechanical Engineering.

The paper by Professor Wohlenberg and Mr. Lindseth outlined a simplified method of dealing with the energy problem of the boiler furnace. The application of this method, the authors claim, yields information concerning that division of total surface between cold furnace walls and convection zone which results in the greatest overall energy absorption. The paper also discussed the influences of fuel type, air preheat, and certain other factors on furnace conditions and surface requirements. B. N. Broido submitted a written comment in which he called attention to several apparent discrepancies which were later cleared up in the authors' closure. One paragraph of the paper, Mr. Broido stated, was of particular interest in that it indicated that the present tendency toward using highly preheated air and decreasing accordingly the boiler surface was based on sound theoretical considerations, in spite of the fact that many might consider it still debatable. J. G. Coutant also discussed the paper orally.

Mr. Yarnall's paper giving particulars of tests of a V-notch-weir tank having a capacity of one million pounds of water and an accuracy of measurement of $1^1/_2$ per cent, was discussed in writing by W. S. Pardoe, A. G. Christie, and J. M. Spitzglass, while C. C. Trump and V. M. Frost submitted comments from the floor. Mr. Yarnall's paper is published elsewhere in this issue.

Others who took part in the general discussion at the session were G. A. Orrok, L. J. Levit, and Abbott Allen.

First Management Session

THE first Session on Management convened at 9:30 on the morning of December 9, C. W. Lytle, Chairman of the Management Division, presiding.

Two papers were presented at this session: namely, Laws of Manufacturing Management, by L. P. Alford, and Production Control, by Clarence G. Stoll.

Mr. Alford's paper, which was published in pamphlet form prior to the meeting, was presented in abstract. A tremendous amount of written discussion was offered, the volume being so great that it was impossible to present the whole of it. It would be impossible even to summarize this material in space here available, but members will have an opportunity to digest the information it contains at a later date when the complete paper and discussion appear in Transactions. Those submitting written comments were: J. W. Roe, H. V. Coes, J. A. Brown, John Gaillard, F. J. Schlink, Wallace Clark, G. C. Harrison, C. M. Bigelow, C. W. Beese, John Younger, B. A. Franklin, R. T. Kent, G. S. Radford, L. Kuvin, and J. A. Brown. Considerable oral discussion was offered, in which the following were a few of the points emphasized: the study of hand grasps; the need to measure and the need to use; the desirability of classifying certain principles and terming them doctrines; and the codification of usable doctrines. Those taking part in the oral discussion were Lillian Gilbreth, Ralph Macy, and R. Poliakoff. Mr. Alford responded briefly in his oral closure, but will amplify his remarks considerably for publication.

Before presentation of the next paper, the Chairman introduced Leonard W. Hatch, who devoted five minutes to a talk on The Mechanical Engineer and Accident Prevention. Late developments indicated that great progress had been made in the reduction of mechanical hazards, he said, but no such progress was recorded where the human element had to be dealt with. Reasons for the existence of these conditions were given.

Mr. Stoll's paper was not received in time to allow publication prior to the meeting, consequently no written discussion was submitted. Some oral discussion was elicited, however, in which R. T. Kent, Percy Brown, and G. M. Ford participated. The working out in practice of the fundamental principles laid down by Taylor was mentioned, also the importance of scheduling. Mr. Stoll replied briefly in his closure to the questions raised during the discussion.

Before closing the session the Chairman called attention to the Division's Progress Report as published in the December, 1926, issue of Mechanical Engineering, and urged all to carefully read it and offer criticisms that would be helpful in the preparation of next year's report.

Machine-Shop Practice—Second Session

THE Second Machine-Shop Practice Session was held on Thursday morning, December 9, under the auspices of the Machine-Shop Practice Division, L. C. Morrow, Chairman of the Sub-Committee on Papers for 1926 Annual Meeting for this Division, presiding.

Three papers were presented: Chromium Plating, by William Blum; The Change of Viewpoint of the Machine Shop, by A. L. De Leeuw; and Theory of Milling Cutters, by N. N. Sawin.

The last-mentioned paper was the only one printed prior to the meeting, this having appeared in the Mid-November issue of Mechanical Engineering. For this reason the papers by Mr. Blum and Mr. De Leeuw were delivered in considerable detail. They appear elsewhere in this issue.

Dr. Blum's paper was of very timely interest and attracted to the session several chemists and metallurgists who ordinarily would not have been present. Though a chemist himself, Dr. Blum confined his paper to the physical characteristics of chromium plating rather than to the chemical features of the process. He called it the outstanding development in the field of plating during the last ten years, but warned against overestimating its possibilities in certain respects, as, for instance, that of rust protection. He emphasized its hardness and tarnish resistance when properly applied.

Mr. De Leeuw gave a clear exposition of the change of viewpoint which has taken place within a comparatively few years in machine shops as a result of the veritable revolution in machine-shop practice which has come about within the past twenty-five years. As Mr. De Leeuw has not only been a keen observer of the changing viewpoint but also one of the active leaders in the revolution of machine-shop practice, he was particularly well equipped to talk on the subject.

Mr. Sawin's paper was based upon experiments upon milling cutters carried on at the Skoda Works in Czechoslovakia. It was of a somewhat complex mathematical nature, and provoked some pointed discussion which indicated that it at least did not conform with American machine-shop-practice ideas. It was discussed by J. G. Beresi, L. F. Nenniger, James A. Hall, A. L. De Leeuw, and R. Poliakoff. As these men have done research work along the same line and have developed practical results therefrom, they added much worthwhile material to the records of the session.

Dr. Blum's paper was discussed by U. A. Mullen from the standpoint of a roller-bearing manufacturer, by B. H. Blood from the standpoint of the gage specialist, and also by R. S. Luce, F. W. Van Orden, Joseph F. Keller, A. E. Flowers, D. H. Chason, and J. S. Pecker.

The remainder of the session was devoted to closures. In answering questions Dr. Blum added what amounted to a second chapter of his paper, based upon the points concerning chromium plating which were of the greatest interest to his audience.

Session on Aeronautics

THE Session on Aeronautics, under the auspices of the Aeronautic Division, was held on the morning of December 9, with Charles L. Lawrance, president of the Wright Aeronautical Corporation, in the chair.

Three papers were presented at this session, as follows: The Fusion-Joining of Materials in Aircraft Construction, by Samuel Daniels; Development and Construction of the Standard Army Parachute, by John Bonforte; and Industrial Applications of the Flettner Rotor, by F. O. Willhofft.

The papers by Messrs. Daniels and Bonforte appeared in the Mid-November, 1926, issue of Mechanical Engineering. The former consisted of a compilation of data available on electric and gas welding and brazing as applied to the joining of aircraft parts. The latter paper described parachute tests, explained the construction of the modern chute, developments in recent years, and pointed to possible improvements in the future. Mr. Willhofft's paper, however, did not appear in print prior to its presentation. In it the author mentioned characteristics of the rotor as established by laboratory tests and experiences with rotorships. Savenius' modification of Flettner's rotor for domestic-size windmills was

mentioned also, as well as the use of rotor ventilators for closed automobiles, buses, railway cars, etc. Rotor windmills as prime movers for electric generators were also described, and details of a 100-ft. wheel given. The paper was illustrated with lantern slides showing results of laboratory tests and practical operation.

A written discussion of Mr. Daniels' paper was offered by W. G. Harvey, in which he mentioned the value of presenting clean parts for welding. He also stated that magnesium or a magnesium alloy wire is now being substituted for steel wire and the cavities filled completely. Arthur Knott, also commenting in writing, mentioned the practice of his company in the welding of aluminum. He also stated that heat-treated metal could be welded if the rod were of the same analysis as the metal. Those discussing from the floor were: Archibald Black, K. M. Lane, J. G. Ritter, and the Chairman. Lieutenant Haase, who presented the paper in the absence of Mr. Daniels, replied briefly to the questions raised.

Mr. Bonforte's paper was discussed at some length by W. Lawrence LePage, who emphasized the importance of the subject of parachute development. Reference to the destruction of the British rigid airship R-38 and the results of attempts to use the parachute in escape from the wrecked craft was made. It was his opinion that the parachute in this case was not a savior but a destroyer of life. Those who clung to the floating ship sections were saved, while the parachute jumpers were drowned beneath the chutes. Guy Ball entered the oral discussion and described tests and gave results.

No written discussion followed Mr. Willhofft's paper. The oral discussion, however, was rather lengthy, and included remarks by Otto Lund, Prof. Alexander Klemin, and the Chairman.

The Progress Report of th. Division was presented by E. E. Aldrin. This report appeared in the December, 1926, issue of Mechanical Engineering under the title Progress in Aeronautics.

Second Management Session

The second Session on Management was held under the auspices of the Management Division and the Taylor Society, and convened at 2:00 p.m. December 9. Percy S. Brown, President of the Taylor Society, presided.

The first paper on the program was that by J. C. Clark on Railroad Organization. In this paper administration, organization, and management were defined; fundamental differences distinguishing the railroad industry, methods of controlling business, functional organization, methods of organization, and coördinating work of various departments discussed. The paper was discussed in writing by Hayes Robbins, who emphasized the lack of development in the human organization as compared with mechanical development.

The paper Vitalizing vs. Centralizing Organizations, by Robert E. Newcomb, discussed the disadvantages of concentration and advantages of discreet decentralization. Written discussions were submitted by W. W. Webber, Frank A. Buese, and John C. Robinson. Mr. Webber saw a burdening of the initial executives in attempts to carry out the recommendations of the paper. He emphasized the importance of training future executives. According to the comments of Mr. Buese, an industrial organization should enable a major executive to develop the powers of his subordinates without excessive friction between them and yet have his policies followed by every one in the organization. He mentioned five "tools of management" for accomplishing this result. Mr. Robinson emphasized the importance of personnel and system.

Before passing to the next paper, the Chairman introduced Lew Palmer, who devoted five minutes to a safety talk.

Jerome C. White presented a paper on An Experiment in Scientific Management in the Coal-Mine Industry, in which he described the installation of a centralized production control in an attempt to overcome relatively great distances separating the comparatively isolated producing units, the miners. His conclusion was that scientific management could be installed to advantage. In a written discussion of the paper, Wallace Clark described conditions in a Polish coal mine with particular reference to operation records. J. C. White and J. N. Carmody discussed the paper from the floor, both emphasizing the importance of the chart method of recording operations.

The final paper on the program was by H. A. Hopf and was entitled Problems of Bank Organization. The paper presented from an engineering point of view specific problems of organization with which modern banks are confronted. It also gave a background of banking development and a description of the functions of a bank. A discussion of the structure, personnel, and special phases of bank organization was given. There being no written discussion, the paper was thrown open to general oral comment. The Chairman spoke briefly against the practice of a bank operating an industry. H. Dennison emphasized these remarks, commenting at considerable length on the subject. R. W. Van Ness spoke from the banker's standpoint and related his experiences with a bank operating an industry which was unable to pay dividends until a thorough analysis was made and a new line of executives installed. In his closure Mr. Hopf expressed the opinion that the mechanical side of industry is outstripping the human side, and that future developments will depend upon the ability of the human side to adjust itself.

Session on Oil and Gas Power

E. J. KATES, Chairman of the Oil and Gas Power Division, presided at the Oil and Gas Power Session, held on Thursday afternoon, December 9, under the auspices of the Division. A rather lengthy program included the presentation of five papers and the Progress Report of the Division.

A short talk on the subject of Safety and Its Relation to Engineering and Economics in Our Every-day Life, by G. A. Orrok, opened the session. Reference was made to the annual loss from industrial accidents of 35,000 human lives and more than $500,000,000. It was the contention of the speaker that while the engineer was not directly responsible through carelessness for these accidents, it was his duty to so improve design that possibilities for accident would be reduced.

Before proceeding with the papers the Chairman asked L. H. Morrison to present the Progress Report of the Division. This Report appeared in the December, 1926, issue of Mechanical Engineering, under the title Progress in Oil and Gas-Power Engineering. Mr. Morrison presented the report in abstract, discussing the important items in passing.

The paper on Kinematics of Cams, Calculated by Graphical Study, was presented at this point by the author, H. Schreck. The application of graphical methods for the calculation of velocity and acceleration of cams was outlined, and the theory of the method explained. Written discussions were presented by P. R. Hoopes and R. C. H. Heck. These contributions were prepared in some detail, and in the case of the latter several diagrams were offered.

E. C. Magdeberger's paper on The Modern Oil Engine appeared in the Mid-November, 1926, issue of Mechanical Engineering. It dealt in the main with attempts of foreign and domestic manufacturers to adapt this type of engine to a constantly broadening field of application. A short oral discussion, also written comments by L. H. Morrison and Albert S. Walker, followed. Those discussing the paper orally were Herman Hugle, Warren Viessman, and Andre C. Attendu.

The development of a graphical method of solution of gas-engine-cycle problems, analogous to Mollier-diagram solutions of steam-cycle problems, was presented in the paper Ideal Gas-Engine Cycles, by R. C. H. Heck.

The two remaining papers on the program were presented before throwing the meeting open to discussion. H. A. Everett's paper on A Temperature-Entropy Diagram for Air and the Diatomic Gases O_2, N_2, and CO, presented a diagram permitting the ready solution of problems dealing with these gases where high temperatures are involved without the necessity of employing the involved or indirect mathematical solutions that take account of the variability of the specific heats. P. H. Schweitzer presented a paper on The Tangent Method of Analysis for Indicator Cards of Internal-Combustion Engines. He showed that the method is simple in execution, is sufficiently accurate, and has been of distinct assistance in testing internal-combustion engines. Both of these papers appeared in the Mid-November, 1926, issue of Mechanical Engineering.

In the joint discussion the following submitted written comment: F. O. Ellenwood, discussing Professor Heck's paper; and Julian C. Smallwood, Professor Heck, R. W. Angus, Robertson Matthews, R. Hildebrand, and H. Schreck, discussing Professor Schweitzer's paper. Considerable oral discussion also followed, into which the following entered: Professor Everett, discussing Professor Heck's paper; Professor Berry, discussing indicator cards, and Mr. Schreck, discussing conditions in the cylinder of a gas engine.

One of the important events of the session was the presentation of the award for the best paper delivered during the Oil and Gas Power Week of 1926 to Fred Thilenius. Mr. Thilenius, however, was unable to receive the award in person, but Chairman Kates accepted the prize for him and responded briefly in his behalf.

Owing to lack of space, a more detailed account of the session cannot be given at this time, but will follow at a later date in Mechanical Engineering.

Machine-Shop Practice—Third Session

THREE papers were presented at the third Machine-Shop Practice Session, held under the auspices of the Machine-Shop Practice Division, W. F. Dixon, Chairman of the Division, presiding. They were: Worm-Wheel Contact, by Earle Buckingham; The Plastic Behavior of Metal in Drawing, by C. L. Eksergian; and The Distribution of Belt Creep and Slip, by R. F. Jones. The Progress Report of the Division was also presented at this session.

A brief talk in which he emphasized the importance of the manager getting into the spirit of safety was delivered by Lew R. Palmer before proceeding with the papers.

Professor Buckingham's paper, the first presented in the session, discussed the determination of worm-wheel contacts by analysis and the influence of nature of contact on lubrication. He showed the analyses of three helicoids. The conjugate action of racks was also discussed and equations given. Contact lines of screw helicoids used as worms and those of involute helicoids used as worms received attention, as did those of screw helicoids with large helix angles, and involute helicoids with large helix angles. The paper was presented in abstract by the author. Written discussions by L. R. Buckendale, George H. Acker, and J. C. O'Brien commented on the value of the methods presented. Mr. Acker stated that his experience indicated that the real loading limitations were determined by the safe fatigue limit of the bronze. Mr. O'Brien felt that the paper would open up new lines of thought. Others discussing the paper orally were T. J. Jeacock, H. Fleckenstein, and H. J Eberhardt.

The object of Mr. Eksergian's paper was to foster the development of analysis to drawing as an aid to subsequent development. No attempts were made to set forth any concrete analysis, but rather to attempt an outline of a manner of attack by which a proper conception of the phenomena might be realized. A survey of conditions observed in stamping operations was made, along with a report of certain experimental investigations which were conducted by the author. A brief discussion by C. F. Nagel followed.

Experiments on slip determination, using standard domestic belts, were described in the paper by Mr. Jones. The stroboscope slip-meter used in the tests and the method followed by the investigators, as well as the theory involved were explained. It was shown that the amount of load carried by a given belt under given conditions at the merging point varied with the coefficient of friction. The paper was discussed in writing by C. A. Norman, and orally by A. A. Adler and C. G. Barth.

The final business of the session was the reading of the Progress Report of the Division, which appeared in the December, 1926, issue of Mechanical Engineering under the title Progress in Machine-Shop Practice. This was read by the Chairman, following which he declared the meeting adjourned.

Session on Petroleum

H. S. BELL, member of Sub-Committee on Papers for 1926 Annual Meeting of the Petroleum Division, presided at the Session on Petroleum, which was held on the afternoon of December 9.

Three papers were presented at this Session, as follows: New Methods of Lubricating Steel-Mill Machinery, by C. H. Bromley; The Boiler House in Oil Refineries, by H. A. Ross; and Modern Fire Fighting in Oil Refineries, by Frank A. Epps. In addition to the papers the Progress Report of the Division for the year was presented.

A short talk on safety in the petroleum industry preceded the presentation of the papers. This was delivered by Roy S. Bonsib, who emphasized particularly, clean living, clean thinking, and real fellowship.

Mr. Bromley's paper, which appeared in the Mid-November, 1926, issue of Mechanical Engineering, discussed lubricating-oil requirements, characteristics of lubricants suitable for gears and journals, gravity- and pressure-type lubricating systems, rates at which oil should be supplied, etc. The paper was presented in abstract by the author. A written discussion by G. B. Karelitz emphasized the desirability of forced lubrication in steel mills. The writer also recommended the use of centrifugal separators to purify the oil and guard against the presence of water. H. M. Brown wrote of his experiences with special lubricating equipment installed in a rolling mill and the coöperation received from the manufacturer of the equipment. Percy C. Day, commenting orally, mentioned the lubrication of heavy herringbone gears in general, with reference to temperatures, bearing pressures, etc.

It was the contention of Mr. Ross that no small refinery could afford, under the prevailing competitive conditions of the business, to continue the operation of old equipment with cheap labor. Lack of coördination in the large, well-manned, modernly equipped plant frequently affected fuel and heat economies, he showed. E. P. Kiehl and D. S. Jacobus, commenting from the floor, emphasized the importance of elimination of waste.

The paper by Mr. Epps, presented by the author in abstract, discussed the causes of fires in tanks or stills in refineries and methods and procedures for prevention. Some of the latter included fire walls, grounding, etc. Operation and maintenance were emphasized, and a foam system described and data on design supplied. Oral discussion followed, H. E. Ramsey and R. S. Hoffman touching briefly on lightning protection and foundations, respectively.

The Progress Report of the Division, published in the December, 1926, issue of Mechanical Engineering, under the title Progress in Petroleum Engineering, was presented in abstract by Chairman Bell in the absence of Walter Samans, who was scheduled to make the report. It was urged that those present read the full report as published.

Boiler-Feedwater Session

THE Boiler-Feedwater Session held under the auspices of the Power Division and the Joint Research Committee on Boiler-Feedwater Studies, convened on Thursday afternoon, December 29, S. T. Powell, Chairman of the Joint Research Committee, presiding.

Progress reports on nine sub-committees of the Joint Research Committee were presented. These dealt with the pretreatment of boiler feedwater; present knowledge of foaming and priming of boiler water, with suggestions for research; the embrittlement of steel; municipal water supply and the effect of trade wastes in relation to the use of water in power-plant practice; corrosion of boilers and effect of treated water in accelerating or relieving these troubles; sedimentation, filters, deconcentrators, and continuous blow-down apparatus; surface condensers, evaporators, and deaerators; and standardization of water analysis.

The first six of these reports were published in the Mid-November, 1926, issue of Mechanical Engineering, pp. 1361–1374. Summaries of the remaining three were presented at the meeting. In presenting their respective reports, C. W. Foulk called attention to the scarcity of literature on priming and foaming, and Prof. A. G. Christie said that in the second paragraph of his report on embrittlement the word "promoted" should have been used instead of "inhibited."

C. H. Coyl, D. K. French, Prof. A. E. White, K. Von Eltz, E. M. Partridge, V. M. Frost, G. D. Bradshaw, E. N. Trump, R. D. Spear, and several of the authors of the reports participated in the discussion. Mr. Coyl pointed out certain advantages in favor of

the intermittent type of water-softening plant. Mr. French said that in a large number of installations his company had obtained perfect results by sedimentation. In these cases there was nothing but the tank and an agitator device, and in four hours' time perfectly clear water was obtained. Speaking of scale deposition, Professor White gave instances of two locomotives, one having boiler tubes containing one-half of one per cent of nickel and the other having ordinary tubes. The scale deposit in the tubes containing nickel was practically nil, whereas in the regular tubes it was very great.

Mr. Von Eltz called attention to the advantages of using barium carbonate in removing the sulphates from water by changing them into barium salts. Mr. Partridge described a treatment which made it possible to keep calcium carbonate in solution for a longer time so that it remained held in actual solution or in suspension in the boiler water, and when the sulphate scale mixed with it, formed a softer scale.

Messrs. Bradshaw and Trump gave numerous instances of the embrittlement of bolts and rivets exposed to the action of caustic solutions. Mr. French told of a test run on one of the railroads near Pittsburgh on a water containing oxygen, and stated that the addition of tannic acid and compounds thereof was as effective in taking care of the oxygen as the open feedwater heater. Mr. Spear told of a Perkins boiler tested by the British Admiralty which ran for thirteen years without a boiler tube being replaced, nothing but distilled water being used.

Gun Tubes and Steel Cylinders

IN A LECTURE delivered before the New York Chapter of the American Society for Steel Treating on December 13, Dr. F. C. Langenberg, metallurgist of the Watertown Arsenal, Watertown, Mass., in addition to presenting many novel facts and data of tests on the manufacture of gun tubes, made several statements, of which the following may be mentioned.

Referring first to the condition of affairs in the forging industry, Dr. Langenberg stated that the production of heavy forgings was developed to a high state during the war. The armistice was at first considered to be a death blow from which the industry was not expected to recover. Actually, however, the heavy-forging industry today is busier than it ever was, and all the equipment available is sometimes working overtime. This is due to the great demand for heavy forgings in the chemical industry.

As regards the effect of internal stresses in cylinders, such as occur in guns and certain cylinders used in the chemical industry, Dr. Langenberg showed a stress-strain diagram from which it would appear that the stress at the wall of the bore is many times greater than the stress at the outer periphery. He stated, moreover, that no increase in strength of a cylinder of that character is secured by making the thickness of the wall greater than one caliber, that is, greater than the diameter of the bore.

Because of the fact that the stress at the outer periphery is only a small fraction of that at the inner bore, there is an advantage in having a metal of the highest possible ductility at the inner bore and of low ductility at the outer wall. During the war, particularly in its early days, there were numerous cases of guns bursting. When this happened the gun tube flew to pieces and the crew was usually killed. If, however, the gun tubes were made of high ductility on the inner wall and low ductility on the outer wall, there might be a spurt of gases, but fragmentation of the tube would not take place. The first method of securing this interrelation between high ductility of the inner wall and low ductility of the outer wall was produced by the process previously described by Dr. Langenberg before the American Society for Steel Treating (Cleveland Convention, 1925. Compare MECHANICAL ENGINEERING, Nov., 1925, p. 919). In this case a gun tube made of steel in a certain condition was subjected to a given percentage of enlargement of the bore, which resulted in producing an unequal elastic strength. Lately, however, another method of achieving the same purpose has been tried namely, centrifugal casting of the gun tubes.

It should be clearly understood that in this instance centrifugal casting was used for a peculiar purpose, namely, to produce deliberately a weaker metal outside and a stronger metal inside. This could obviously be accomplished by inducing in the metal a state of uneven distribution of carbon, with the percentage in the outside material different from that in the inside (0.15 to 0.50).

With this in view, gun tubes 10 in. in outside diameter and 15 ft. long were cast from a three-ton electric furnace in a mold provided with a heavy refractory lining, the metal being dumped in by a spout very rapidly. Because of the great thickness of the wall (apparently not less than 5 in.) and the presence of the refractory lining the freezing of the metal proceeded at an extremely slow rate, stated by Dr. Langenberg to have been of the order of $1^1/_2$ hr. or more. As usually happens in such cases, the heavier particles were thrown on the outside and the lighter particles on the inside producing a state of segregation or rather uneven distribution of metalloid compounds, which happened to be the very distribution desired for this particular purpose.

As regards the structure of the metal thus cast, it does not appear that it differs from that of an ordinary steel casting. As a matter of fact, there is no particular reason why it should so differ, since once the metal has been delivered to the machine its structure is controlled by the rate of cooling in the same manner as the structure of a casting made in a stationary mold, the centrifugal force itself being apparently incapable of affecting the structure or changing it in the face of the action of the other factors. In reply to a question from the audience, Dr. Langenberg explained that far from being a disadvantage, this is a desirable characteristic. In ordinary forging of a cylinder the strength of the metal in one direction is very great, while in another direction it is quite low. It is only in mandrel forging that the stress is in the direction desired for a gun tube. On the other hand, in a casting the strength is the same in all directions. Dendrites are present, but may be easily destroyed by subsequent heat treatment.

A photograph of a section of a tube cast showed plain indications of laminar structure, and the section seemed to consist of several rings somewhat like those of a tree trunk. The inside surface seemed to be rough and irregular, and several longitudinal cracks on the inside surface were plainly discernible. The tube was cast of such a thickness that sufficient material might be removed until solid metal was reached.

In the discussion which followed it was pointed out that unequal distribution of carbon in the castings shown by Dr. Langenberg was due not to the use of centrifugal force but to the fact that an extremely slow cooling was artificially induced by dumping the metal into the mold at a very fast rate, combined with the use of refractory lining. It was pointed out that it is perfectly possible to produce a centrifugal casting free from segregation and unequal distribution of metalloid compounds by a proper control of the rate of freezing, and particularly by making it very fast.

In the second part of his paper the author presented an interesting comparison between the impact strength and the tensile strength of steel. He showed that substantially the steel with a high tensile value will also show a high impact value and vice versa, although the work values are not the same in both cases. It is true that cases have been known where two samples of steel of apparently the same elongation and tensile strength have shown widely different impact values. He took two such samples and determined their elongation in a manner different from the current one: namely, instead of determining the elongation over the total length of, say, 2 in., he divided this length into sections each $^1/_{16}$ in. long. When he determined the elongation of these small sections, a very surprising phenomenon was discovered. In one sample the elongation of all the sections was approximately the same, while in another sample a section was found having an elongation something like six times the elongation of the corresponding section of the other sample. The sample with a greater local elongation showed also a higher impact value, which in this case was due to the peculiar condition discovered.

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers and Proceedings of

The American Society of Mechanical Engineers

29 West 39th Street, New York

The Annual Meeting

A REGISTRATION of 2213 was recorded at the Annual Meeting of the A.S.M.E., recently held. This tops previous figures and sets a new mark for program makers to exceed.

Registration figures are matters of great interest to members and committees in charge, but generally they successfully defy analytical comparison with figures of other years. With complex programs of over twenty sessions, it is impossible from registration figures to determine why one meeting attracted two hundred more than another. One conclusion which is self-evident from the figures is that the number of members who come from outside New York is increasing rapidly. This is encouraging as it indicates that the Annual Meeting is more and more coming to be the great national clearing house of mechanical-engineering discussion.

The most important function of an A.S.M.E. Meeting is the opportunity it offers for members to become acquainted and to interchange information and experience. Some of this opportunity is provided in the formal sessions and committee meetings, but the major portion is provided in the lobby on the ground floor of the Engineering Societies Building. This foyer is the most valuable portion of the building for a great Society meeting, and the members of the A.S.M.E. make good use of it.

Engineering and Modern Physics

THE science of physics, both in theory and experiment, has made such astonishing progress in the last twenty-five years that the question has been raised by some whether the new points of view in physics might not have serious effects on the theory and practice of engineering.

It is well known that many physicists at the close of the last century felt that their science had reached a state of comparative perfection. Some declared that further progress lay merely in the determination of additional significant figures in the values of natural constants. The wave theory of light accounted for everything in optics—almost. The mechanical theory of heat seemed to admit of no improvements. Mechanics rested securely on Newton's laws of motion. Maxwell's theory of electricity and magnetism had enjoyed triumphant vindication in Hertz's discovery of the electric waves predicted by it. These were being applied by Marconi to the purposes of radio communication.

But there were those who expressed their doubts, perhaps remembering that Newton had said that he felt like a child playing with pebbles on the shore of the ocean of knowledge. The rank and file of physicists knew that something was wrong with the theory of radiation, and that as yet no one had given any reasonable explanation for the wondrous complexity of the spectra of substances shown when their vapors are made to give out light by excitation in a discharge tube or in the electric arc or spark.

The discovery of X-rays in 1895 and of radium in 1898 and the intense activity which followed in the study of the behavior of electrons soon dispelled any complacency which the physicist may have felt about the perfection of his science. In 1900 Planck introduced a new and successful theory of radiation, based not upon the wave theory of light but upon the concept that energy is radiated from an atom in discrete amounts or "quanta." This idea was given strong support by Einstein, who used it successfully to explain the photoelectric effect; and in 1913 Bohr made it the basis of his theory of atomic structure. This theory has been developed and modified, so that today we have a remarkable body of organized knowledge of the spectra of elements and compounds that could not possibly have been foreseen. Directly in line with these developments came the discovery by Moseley of the isotopes of the chemical elements, and by Compton of the effect which bears his name. In the meantime Einstein by his theory of relativity had shown that even the laws of Newton were susceptible of refinement.

In this way it has come about that modifications and new points of view have been introduced into all parts of physics. The knowledge accumulated in the past thirty years is more in volume and in variety than had been accumulated in all time before.

Out of all this has come a clarification of great numbers of problems in chemistry. Knowledge of the behavior of electrons has resulted in an enormous development in the variety and uses of characteristics of the three-electrode vacuum tube so widely used in wire and radio communication. The structure of crystals has been elucidated by the use of X-rays. Recent researches in the excitation of hydrogen in the tungsten arc have given the world a welding process which may have a great effect on the entire industry of steel construction and on all the arts requiring high temperatures. Applications of the photoelectric effect are already innumerable.

The most intensive work being done at the present time is in the extension and application of the quantum theory. The outstanding mystery, the one whose solution is most eagerly sought, concerns the manner in which radiation and matter react on each other. It is in this domain, if in any, that we are to hope for some means of using the energy bound up in atoms, or perhaps the direct transformation of solar energy into forms convenient to use.

It is evident that no fact of nature can be changed by any theory, and new facts do not invalidate old ones. On the contrary, it always happens that new facts illuminate the old; the newer theories as a rule are more general and more inclusive than those of the past.

The bond between pure and applied science is closer than ever before. The great industrial-research laboratories have been quick to seize the methods of modern physics and to apply them to their problems. Engineering makes applications of facts rather than of physical theories. The shifting bases of theories do not invalidate the facts they try to explain. Instead of tearing down the superstructure of engineering science, another story is being built upon it.

J. C. Hubbard.[1]

The Coal Conference at Pittsburgh

THE Carnegie Institute of Technology has the hearty congratulations of the engineers of the country for the successful outcome of the Bituminous Coal Conference held at Pittsburgh under its auspices during November. This meeting, which is reported in another column, brought together the experts of the world on a problem of tremendous importance to industry. It served as an opportunity for publicity for scientific research and as a stimulus to further investigation. The papers and addresses showed that in the main the more complete utilization of the products of bituminous coal is still in the laboratory stage. Engineering data

[1] Professor of Physics, New York University.

are lacking, but with the great number of investigators at work in the field this information will be forthcoming when it is needed.

The Engineer—Wage Earner or Professional?

THE status of the engineer is a frequent topic of informal discussion. However, at an evening meeting on December 15, 1926, the New York Section of the American Society of Civil Engineers brought out for public discussion the subject: The Engineer—Wage Earner or Professional? Three papers were presented, and there was a wealth of discussion from the floor.

The outstanding impression gained from the meeting was a recognition of the fact that the engineering profession as at present constituted includes several groups, and that no general principles can be applied to all these groups and no general statement made as to the opportunities that are open to young engineers.

Broadly defining a professional as one who works as an individual, George L. Lucas, Division Engineer, Board of Transportation, New York City, pointed out that corporations with groups of specialists must exist, immediately reducing individual action. Describing conditions in an organization of 1240 engineers, he showed that although 40 per cent of the men held degrees, the best interests of the corporation and the public demanded the retention of these men in their respective special departments. Shifting from one position to another to gain experience would affect the overall efficiency of the organization.

Mr. Lucas suggested employing specially trained technicians for the simpler positions and permitting the men with degrees to pass more rapidly through the departments to higher positions in keeping with their training.

The remedies suggested in open discussion were many and varied. Some advocated curtailment of college enrolments; others the licensing of engineers; still others the refusal to accept purely technical positions; even the formation of a union of engineers was recommended. These facts, however, stood out most prominently:

First, a man's position in life depends largely upon his own initiative; second, economic conditions demand the corporation with its corps of specialists; third, no man can hope to become a factor in his field and dictate his own terms until he can match wits with a client and stand or fall on his ability to estimate the magnitude of a given problem; fourth, an engineering education is not wasted, no matter whether one follows engineering or enters business.

The Basic Process of Engineering Education

"THE basic process of engineering education should be an undergraduate curriculum of coherent and integral structure, directed to the grounding of the student in the principles and methods of engineering and in those elements of liberal culture which serve to fit the engineer for a worthy place in human society and to enrich his personal life."

The foregoing paragraph is one of the fundamental recommendations in the preliminary instalment of the Report of the Board of Investigation and Coördination of the Society for the Promotion of Engineering Education. This report, which contains the first definite recommendations resulting from the three-year study carried out under the grant of funds by the Carnegie Corporation of New York, was presented at a meeting of the Division of Deans and Administrative Officers of the S.P.E.E. held in Washington, D. C., on November 18 and 19, 1926.

A distinguished gathering of engineering educators, including 29 presidents, 67 deans, and 23 professors, met at dinner at the Willard on November 18. Prof. C. F. Scott, of Yale, Chairman of the Board of Investigation and Coördination, presided, and the report was presented by Dr. Frank Aydelotte, President of Swarthmore College. Two sessions were held on November 19 under the chairmanship of Dean Milo S. Ketchum of Illinois, Chairman of the Division of Deans and Administrative Officers, S.P.E.E. The report was presented for discussion in sections by William E. Wickenden, Director of the Staff of Investigation. The discussion lasted for the entire day, at the close of which a resolution was unanimously adopted endorsing the report and urging its study by the several faculties with a view to placing its recommendations into effect.

The report, which will be abstracted in the February issue of Mechanical Engineering, covers seven subjects, as follows: I—Structure of Undergraduate Curricula; II—Social and Economic Content of Engineering Curricula; III—Admissions; IV—The Non-Graduating Student; V—The Work of Exceptionally Gifted Students; VI—Teaching Personnel; VII—The Scope of Engineering Education. The complete report appeared in the December, 1926, issue of the *Journal of Engineering Education*.

Steam Locomotives

FOR several years the value of electricity as a motive power for railroads has been emphasized in engineering literature. An expression of faith in the steam locomotive as a dominant factor in transportation is therefore worthy of more than passing notice. This note was sounded recently by none other than L. F. Loree, President of the Delaware & Hudson Company, on the occasion of the award to him of the 1926 medal of the Holland Society.

Mr. Loree pointed out that the contest between electric haulage and steam haulage may be expected to be continued in the future, but while one or the other of these methods of transportation would possibly usurp or stabilize itself in restricted fields, the dominance in the larger aspects will depend largely upon the ability, genius, courage, and tenacity of the exponents of the two methods. He expressed his abiding faith that for the main purpose of the railroad —the transportation of heavy articles over long distances—the unit system of transportation (steam locomotive) will be the dominant one.

Tremendous advances have been made in steam transportation in the past five years, and Mr. Loree's words will encourage mechanical engineers to still further progress in a field which offers great opportunity for advances.

Wilfred Lewis Nominated as A.S.M.E. Medalist for 1927

THE Committee on Awards has nominated Wilfred Lewis as the A.S.M.E. Medalist for 1927. As provided in the rules of the Society, this nomination must be published thirty days prior to the selection of the medalist by the Council.

Mr. Lewis has been cited for this honor for his contributions of research and analysis to the problem of gearing. He has led thought and experimentation in gearing for forty years, both nationally and internationally. He has contributed valuable engineering work to the public without thought of reward. He was a pioneer in the application of scientific methods to the study of gears, and from this resulted the development of his well-known formula for the strength of gear teeth.

Mr. Lewis joined the A.S.M.E. in 1884 and since that time has taken an active part in its committee work and public meetings. He was first employed by William Sellers and Company as a machinist, and later joined the Tabor Manufacturing Company. His principal original contribution to the advancement of mechanical engineering is in connection with his work on the testing of the strength and wear of gear teeth.

This study of the subject began when he was in the employ of the firm of William Sellers and Company. At that time he read a paper before the Society entitled Experiments on the Transmission of Power by Gearing.[1] Twenty-five years later, at the joint meeting of the A.S.M.E. and the I.M.E. held in Birmingham, England, he described the first machine he had built to determine the friction loss of gears under various speeds and pressures. This machine was set up and run at the Massachusetts Institute of Technology.

In his discussion of the paper on Efficiency of Gear Drives[2] presented to the Society by Messrs. C. M. Allen and F. W. Roys in 1918, he described his second machine built for use at the University of Illinois.

The third machine which he designed was described in the December, 1922, issue of Mechanical Engineering. It was built by the Special A.S.M.E. Research Committee on the Strength of Gear Teeth. The test work on this machine is now in progress at M.I.T.

[1] Trans. A.S.M.E., vol. 7 (1886), p. 273.
[2] Ibid., vol. 40, pp. 112–116.

Air Transport Discussed by Metropolitan Section

On November 23, 1926, the Metropolitan Section of the A.S.M.E. met for a discussion of Air Transportation in the Engineering Societies Building, New York City, with Archibald Black[1] in the chair. J. Trippe[2] delivered a talk on Safety of Air Transport, illustrated by numerous slides, and J. E. Whitbeck[3] read a paper on Recent Progress in Air Transportation. The papers drew forth many questions, and a lengthy but informal discussion followed.

Safety of Air Transport

Mr. Trippe said that the last three or four months had seen vast progress in American air transport. The operators were all busy, although they had not yet found their efforts remunerative. Fortunately the aids to navigation now being supplied by the Department of Commerce would relieve them of approximately 30 per cent of what their total costs would be were they to operate without Government aid. Influential and well-informed business men were financing these new lines, and organized schedules for passengers, freight, and express matter might soon be expected in addition to the carriage of mail as at present. The American Railway Express Co. had recently contracted with the National Air Transport Corporation for the carrying of express matter between Chicago, Ill., and Dallas, Tex., and similar contracts would rapidly follow.

The hazards still encountered in air transport, Mr. Trippe said, might be classified as (1) structural failure in the air, (2) instability, (3) fire in the air, (4) the human element, (5) unfavorable weather, and (6) power-plant failure. Structural failures had been common in the early days of aviation, but had now been almost entirely eliminated. The new regulations of the Department of Commerce would call for certain minimum safety factors, which would help. The substitution of metal for wood tended to increased safety and more assurance from a structural point of view. Instability was found very rarely in modern planes, and loss of control did not follow readily any mistake in piloting made by the aviator. By placing the air intake of the carburetor outside the cowling, the danger from backfires had been largely reduced. The gravity feed system for the supply of fuel had eliminated many pipes and lessened the chance of fuel leakage. The human element would always remain, but modern planes were made much easier to fly and much more comfortable for the pilot; it was now no harder to fly than to operate a motor bus. Unfavorable weather remained a hazard, but the improvement in navigational instruments, the radio compass, and similar aids were lessening the dangers from this source. The radio beacon gave promise of great utility. With a radio beacon and a system of auditory signals the pilot could follow an airway even when it was completely obscured by fog. Neon lights, comprising long glass tubes filled with very pure neon gas, with high voltage applied at their ends, gave a reddish glow which had considerable fog-penetrating qualities and was likely to prove very helpful. The fear of forced landing due to engine failure still remained, but the power plant was constantly becoming more reliable. Statistics of the U. S. Air Mail Service showed that of the engine failures, 30 per cent were due to the water system; 29 per cent to the ignition; 11 per cent to the carburetor; and 8 per cent to the lubrication system. The British Imperial Airways reported similar figures. The general use of the radial air-cooled engine in which the water system was entirely eliminated therefore served to increase the reliability to a large extent. On the Colonial Air Lines between New York and Boston there was now only one engine failure in 700 hours of flying. The employment of multi-engined planes reduced the hazard of forced landing very largely. The chance that all engines would fail simultaneously was 1 in 600,000,000, approximately, and the use of separate fuel and oil systems for each engine gave the greatest security.

Mr. Trippe quoted some statistics of European countries in the matter of reliability, and stated that in the last fiscal year the U. S. Air Mail had lost only two lives in two and a half million miles of flying. In Europe the insurance rate of goods for carriage by air was actually lower than for any other form of transportation. In Germany no added premiums were required to cover life or accident risks for travelers on recognized air lines.

Mr. Trippe hazarded a few predictions. He thought there would soon be several lines running west out of New York City, one by way of Pittsburgh, and one by way of Albany and Buffalo, in addition to the existing Cleveland-Chicago route. There would also be a series of air lines running north and south; he thought New England would be connected with New Orleans, for example.

Recent Progress in Air Transportation

In his paper on Recent Progress in Air Transportation, Mr. Whitbeck stated that there were now twenty air lines in regular operation. Fifteen of these had mail contracts, and nine were carrying passengers as well as mail and express. Seventeen had started operations in 1926, which might be considered as a historic year. This progress derived from the five years' successful operation of the Air Mail. He thought that the new law providing for the licensing of pilots and the certification of aircraft would be a great blessing to the industry if it were applied in the proper spirit, and not in the bureaucratic manner which had done so much to hamper commercial aviation in England. The drastic regulations in England were now in process of revision. The recent legislation also provided for the establishment of airways by the Government, although airports were left to municipal and state initiative. He thought it very significant that during the last two years more than a hundred large cities throughout the country had petitioned the Post Office Department for the establishment of air mail. It was only the passing by Congress of laws permitting the Post Office to contract for the carriage of air mail by private concerns which had rendered the present extension of air-mail facilities possible. There was no doubt that air transport would soon embrace the carrying of passengers also. As a matter of fact, in the last few months, 12,000 passengers had paid $300,000 to ride on regularly organized air lines, showing a tremendous increase over previous years. It was significant that 60 per cent of these passengers had traveled in enclosed-cabin planes. To make air travel dependable in the future, real attention had to be given to such matters as the selection and equipment of terminal fields, the provision of emergency landing fields along the routes, and the lighting of the airways with beacons, as well as the provision of both visual and radio signals to the pilot. Reports of weather disturbances were a vital matter. In regard to equipment, several American companies were now manufacturing excellent commercial planes, one new design providing for fourteen passengers, in addition to the pilot and mechanic. Modern airplane engines were constantly increasing in reliability and were far superior to the wartime product. Another recent development for the progress of air transport was that over 200 cities had recently passed legislation permitting them to construct terminal fields or airports, and many other cities were reserving suitable locations for future use. He thought that the design of airports and fields was a matter for skilled engineering and could not be safely left to pilots without special experience in the design of such fields.

Points Brought Out in the Discussion

In the discussion which followed, a number of interesting questions arose, some of which were answered jointly by the two speakers of the evening. It was pointed out by Mr. Trippe that the reason the automobile builder had not taken so kindly to the air-cooled engine was because in the automobile there was not always present a steady and rapid stream of cooling air. In a discussion of engine reliability it appeared that the old Liberty motor had a life of only 500 hours, and an overhaul period of 100 to 125 hours. An air-cooled engine now needed overhauling only once in 300 hours, and its life ran to some 1500 hours. R. J. S. Pigott[4] pointed

[1] Consulting Air Transport Engineer, Garden City, N. Y. Mem. A.S.M.E.
[2] Vice-Pres., Colonial Air Lines, New York, N. Y.
[3] Vice-Pres., W. E. Arthur & Co., New York, N. Y.
[4] Consulting Mechanical Engineer, Public Service Products Co., Newark, N. J. Mem. A.S.M.E.

out that while the life of a turbine running 6000 hours a year was 12 years, the weight per horsepower was at least 35 lb., whereas in aviation practice it was more likely to be 2 lb. per hp. In general the air-cooled engine was replacing the water-cooled type; thus in Europe the Dutch lines were replacing the Napier Lion engines with Bristol Jupiters. Another discusser stated that the Ford Motor Co. was about to go into production on its three-engined plane, at the rate of two a week.

In answer to a question from the floor, Mr. Trippe stated that the rotary air-cooled engine was largely obsolete, 15 to 20 per cent of its power going into overcoming windage losses. Discussing the substitution of wood for metal, Mr. Pigott thought that the lack of certain qualities of woods might hasten the change even apart from engineering reasons.

Members were greatly interested in the amount of plane equipment required for a given air line. Examples quoted by the speakers of the evening were the Colonial Air Lines, between New York and Boston, whose planes make one flight of 1 hr. 15 min. each way, three planes in all being required; the Philadelphia-Washington air line, on which the planes are kept in the air four hours a day, and two planes suffice for the two round-trip services per day.

There was much discussion of the comfort of passengers, particularly as regards noise. Enclosed cabins, long exhaust pipes and mufflers were pointed out as the most likely remedies. Altitude had considerable effect on the ears. A passenger might make a perfectly satisfactory trip one way, and return at a higher altitude and find himself deaf for a period of several hours after landing.

The interest during the evening among members other than those interested in aeronautics professionally was most marked and encouraging.

Wood Industries Division of A.S.M.E. Holds First National Meeting in Chicago

PROBABLY the most important development in the work of the Professional Divisions of the Society during the past year has been the institution of divisional meetings, national in character, quality, and scope, but devoted particularly to the work of the sponsor Division. The first of these national meetings to be held was that of the Wood Industries Division in Chicago on November 23, 1926.

Few people realize to what an extraordinary magnitude commercial and mechanical operations in wood have developed during the past two or three decades. Mechanical engineers of the older branches were once inclined to think of all woodworking in terms of carpentry or hand joinery; but today the woodworking trades are among the most insistent seekers for improved automatic machinery wherewith to facilitate production and speed up their processes.

Moreover, diminishing supplies of suitable woods from our depleted forests call insistently for mechanical conservation in the factories and for the elimination of waste. The woodworking industries are attempting to put into operation methods of precision such as hitherto only workers in iron and steel have been able to apply. In all this the Wood Industries Division of the A.S.M.E. is taking a large and leading part.

Papers Presented

At the meeting, Sern Madsen, of Clinton, Iowa, presented an illustrated paper on sash and door manufacturing, many lantern slides picturing the latest and most efficient types of machinery for automatically performing the operations of mills which are engaged in this large industry. Mr. Madsen is one of the foremost designers of such machinery. His paper was published in MECHANICAL ENGINEERING, December, 1926, p. 1453.

M. E. Dunlap, of the Forest Products Laboratory, U. S. Forestry Service, Madison, Wis., read a paper on Moisture-Resistant Coatings for Wood, a subject in which he has made special studies and which is of importance to every manufacturer of wooden articles. Mr. Dunlap's paper appeared in the December, 1926, issue of MECHANICAL ENGINEERING, p. 1457.

Major George P. Ahern, of the Tropical Plant Research Foundation, Washington, D. C., read one of the most important papers ever delivered at a meeting of woodworking engineers. His subject, The Aim and Scope of Research into Tropical Woods, told of the epoch-making investigation which he and his associates are carrying out at the behest of the A.S.M.E. for the purpose of discovering what, if any, tropical species of woods (from Central and South America, the Philippines, the East Indies, India, etc.), may be found practically usable for American woodworking requirements in the place of native species of which the quantity or the quality is deteriorating.

Major Ahern's paper gave rise to a great deal of discussion, as did also a very interesting motion-picture illustration which brought visibly before the audience the extent to which the available timber of the country has been dissipated. His paper and the discussion thereon, together with a summary of the discussion on the papers presented at the meeting, appears elsewhere in this issue.

Two Sessions at Meeting

The meeting was divided into two sessions, one beginning at 4:00 o'clock and the other following a dinner, all held at the City Club of Chicago. The Chicago Section coöperated in holding the meeting and its chairman, Colonel Hugo Diemer, introduced the chairman of the executive committee of the Wood Industries Division, Wm. Braid White, both at the afternoon and evening sessions. President William L. Abbott was present at the dinner and addressed the audience of about one hundred executives and engineers interested in this important subject. He pointed out the desirability of keeping common interests intact through a parent organization in distinction from forming independent, small, and highly specialized groups. He also felt this type of meeting was designed to give greater importance to meetings in Local Section territory and to avoid continuing to have the overcrowded programs that are customary at the Annual and Spring Meetings of the Society. He heartily endorsed this type of meeting and complimented the members of the Society serving on the two committees which have been instrumental in bringing it about.

The discussion on the first three papers was so extended that it was necessary for Chairman White to ask Thomas D. Perry to confine his remarks on Technical Education in Woodworking, Its Status and Prospects, to a digest of the paper he had prepared on the subject.

Commenting on the fact that barely a third of the lumber cut appears in the form of finished product, Mr. Perry stated that in his opinion there was every real opportunity for an engineering society to interest itself in the subject and emphasize the need to the industry of technically trained woodworking executives, and to the schools that here was a fallow field of almost untouched opportunity and possibility for graduates to go out and win a living by doing some of the fundamental things that had been done in many other industries that were better established. Unfortunately, he said, there was at present almost nothing in the technical-school field offered to the woodworker, and yet the industry was the sixth in size in the country, with its four billion dollars of annual product.

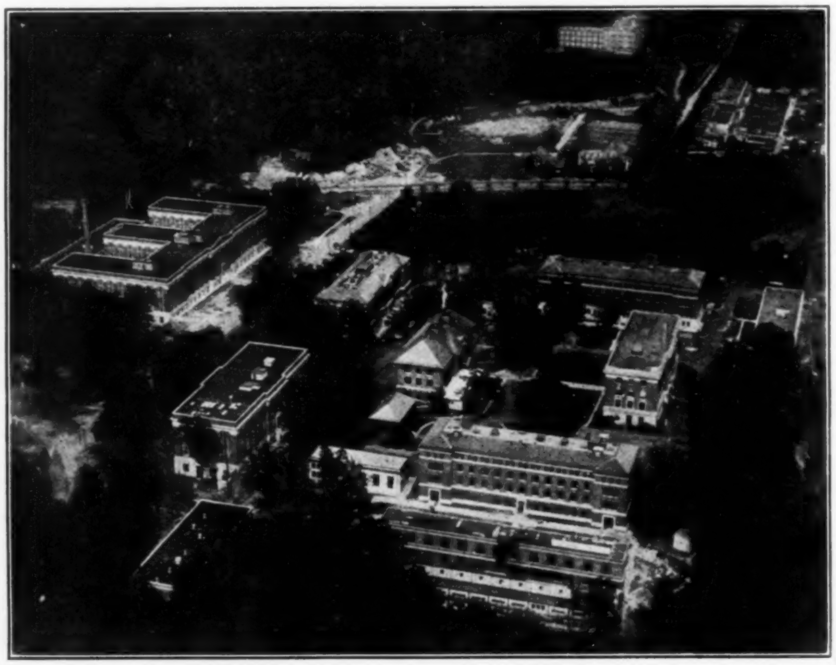
Chairman White covered the most important phases of his own suggestions—Opportunities for the Engineer in the Woodworking Industries—in the course of his remarks in introducing the speakers during the afternoon and evening. A motion picture showing the construction of pianos and player pianos was shown during a brief intermission after dinner.

25th Anniversary of the Establishment of the Bureau of Standards

THE twenty-fifth anniversary of the Bureau of Standards was celebrated in Washington on December 4, 1926. A gathering of distinguished persons visited on that day the beautiful laboratories of the Bureau and then had dinner at the New Willard Hotel. The following is a brief summary of the addresses made at that dinner.

It was only fit that the first address should have been made by Hon. Herbert Hoover (Hon. Mem. A.S.M.E.) both in his capacity of Secretary of Commerce administering the Bureau of Standards, and as the only engineer in the Cabinet.

"This Bureau," said Mr. Hoover, "today represents the greatest of all the world's physical laboratories. It has contributed probably more than any other of our scientific institutions in its special field of development of standards, the development of precision in measurements, and precision in thought, for while science is the growth of knowledge in the fundamental laws of nature, we can make no progress in science unless we may have that development of precision in thought and the determination of accuracy in measurements. We find that the foundation of all scientific progress must be always step by step in the development of terminology, the definition of terms, and, as I said, above all in precision of thought and precision of measurement.



Airplane View of Bureau of Standards

Bureau's Income Larger than That of Most Universities

"I know of no laboratory, no effort of any government that represents so liberal and so generous a support to science as is exemplified in the Bureau of Standards. Today its appropriations approximate two and a quarter million dollars a year, a larger income than most of our universities, an income probably not exceeded by more than five or ten of our great educational institutions, and it all marks an appreciation of the importance of science as a contribution to national progress.

"I am impressed with the fact that we are a people of 110,000,000 on a continent where we have already developed the large proportion of our national resources, a population growing at a rate that we must face in the next fifty years, doubling up to perhaps two hundred million people. We must face the solemn economic fact that unless we develop through science the greater utility of our resources, expand by discovery their usefulness, we cannot maintain the standards of living of that vast increment of population to those standards that we now enjoy.

"Dr. Malthus a century ago brought forth a theory, with which you are all familiar, that an increase of population would be met with pressure on subsistence which would defeat its own purpose. The Malthusian doctrine has not proved true. It has not proved true due solely to the development of science and the discovery of its applications, and today we are just in that same race of population and science. It is only through the support of agencies of this character, and hundreds of other institutions engaged in scientific research, that we may expect with confidence that as our population grows we can still add this increment of comfort and luxury which we have enjoyed in the last century."

Early Days of the Bureau

Dr. Frank A. Wolf told of the early days of the Bureau when it was part of the Coast Survey. In those days the quarters assigned for its work consisted of two basement and sub-basement rooms of the main Coast Survey Building on Capitol Hill, with the coal vault beneath the sidewalk set aside for precision length measurements. In recounting the fight made to obtain from Congress the establishment of an institution along the lines of the present Bureau of Standards, Dr. Wolf recalled an incident connected with Dr. Brashear, saying:

"Dr. Brashear, who did so much for the precision construction of plane surfaces, had been testifying and the committee was struck dumb by what he told them. One of the members, Representative Cushing of Washington, came back at him with this question, 'Do you mean to infer that if I took the little end of nothing and whittled it down to a fine point and therewith poked the pith out of a mouse hair, you could measure the cavity thereby produced?' Dr. Brashear promptly answered, 'That would be easy;' though he admitted that he was unable to quite follow the Congressman's line of thought."

Hon. Robert B. Howell, U. S. Senator from Nebraska, who followed Dr. Wolf, advocated the establishment within the Bureau of Standards of a Division of Economic Research.

The next address was by Geo. B. Cortelyou, former Secretary of Commerce, and now president of the Consolidated Gas Co. in New York City. Among other things, he paid tribute to the men carrying on the work at the Bureau of Standards.

"For a pointed illustration of the truth of these observations," he said, "we need look no further than the Bureau in whose honor we are met tonight. Here we find hundreds of men of high scholastic attainments working in libraries and laboratories, devoting their lives to study and research of the most intricate and technical character, about which the public knows so little but from which it benefits so much. They are part of that small and select company of scientific investigators who in their several fields are true pioneers of progress, ever pushing forward the frontiers of knowledge and harnessing the forces of nature to the service of man. To the world at large they are, with rare exceptions, condemned to perpetual anonymity, but their service to mankind is immeasurable. When Thomas A. Edison was asked by a newspaper interviewer not long ago to name the four most useful men he knew, the great inventor replied, 'Oh, you wouldn't recognize them. They're working around in laboratories.'"

Bureau Touches Every Phase of the Country's Industrial Life

After pointing out that directly or indirectly the activities of

the Bureau of Standards touch every phase of industrial life of the country and contribute in marked degree to the means by which that life has been raised to its present eminence among the nation's of the world, Mr. Cortelyou referred in some detail to the two industries with which he is connected, the gas and electric utilities, and indicated some of the many points of contact between them and the Bureau. This part of the address is omitted with regret, because of lack of space. The speaker concluded his remarks with the following quotation from an address made to a gathering of the Alumni of Amherst College in Boston, in 1916, by a gentleman who has since become President of the United States:

"The hope of tomorrow lies in the development of instruments of today. The prospect of advance lies in maintaining those conditions which have stimulated invention and industry and commerce. The only road to a more progressive age lies in perfecting the instrumentalities of this age."

Dr. S. W. Stratton (Mem. A.S.M.E.), former Director of the Bureau of Standards, referred among other things to the relation of the Bureau to the other departments of the Government. He said:

"There was early established a very friendly relation between the Bureau of Standards and the bureaus of the Government requiring scientific advice and assistance. I could recall hundreds of instances where we have been called upon to develop devices or assist in developing them. One of the first to come to my mind was the problem of a device for plotting a salvo of shots for the Navy. Then there was a long line of them before the war. Perhaps the most conspicuous was the development of the radio direction finder, a problem definitely placed before our experts due to serious collision at sea and for the purpose of devising some instrument to measure the position of ships at sea. This was developed and we all know its usefulness not only in coastwise navigation but in military affairs. It was given to the Navy. The Navy used it with great success, and used it with great efficiency during the war."

Meeting of American Society of Refrigerating Engineers

THE American Society of Refrigerating Engineers held its twenty-second annual meeting, December 6 to 8, 1926, at the Hotel Astor, New York City.

The report of the Corrosion Committee on the Prevention of Corrosion in Brine Tanks was one of the features which attracted considerable attention.

The effect of alkalinity, oxygen concentration, velocity, and other factors had been studied before, so the work consisted mainly of searching for retarders, which, when added to the brine in the proper concentration, would decrease or eliminate corrosion of both bare and galvanized metal. The influence of sodium chromate on the corrosion of iron and steel by calcium brine was discussed. It was found that the addition of sodium dichromate to the brine gave a protection to iron and steel when the dichromate was neutralized, that is, converted to sodium chromate by the addition of caustic soda. In other words, sodium chromate is a more efficient retarder for iron and steel than the dichromate per unit of chromium in the brine. However, because of its common use in the arts, the dichromate is cheaper and more readily available than the chromate. It is therefore advisable to purchase the dichromate and neutralize it in the brine tank, rather than to buy a commercial mixture.

If the 76 per cent commercial flake caustic soda is used for neutralization, 35 lb. should be added for each 100 lb. of dichromate. Slightly less than this amount of caustic is necessary if the brine is alkaline before treatment.

The most effective concentration of dichromate to use is 200 lb. per 1000 cu. ft. of brine. It is not advisable to use this salt in open systems, however, because the workmen handling the brine are liable to be affected by "chrome itch." This can be avoided if the men will observe cleanliness.

Tests on galvanized material, brass, bronze, and Admiralty metal showed that about 90 per cent protection to these metals could be obtained by the use of dichromate neutralized with caustic soda.

For open systems bi-sodium phosphate was recommended for open brine tanks, although the results were not so good as with the chromate. On the other hand, tests revealed that sodium silicate was of little use as a corrosion preventive.

The question of operating costs of a cold-storage plant, always of interest to engineers, was considered by Geo. A. Horne in a paper entitled, Cold-Storage Operation Data, and dealing with a New York City plant on the basis of the mean ton-day of refrigeration. These costs were given in the form of a table as follows:

ANALYSIS OF POWER-PLANT COST PER MEAN TON-DAY OF REFRIGERATION

Direct Charges:	
Maintenance, labor, and materials	$0.260
Lubricants	0.007
Light and power (electricity)	0.530
Calcium chloride	0.006
Ammonia	0.000
Operating salaries and wages	0.350
Miscellaneous supplies	0.027
Total direct charges	$1.180
Indirect Charges or Overhead:	
Interest, 6 per cent on investment, including building and machinery	0.344
Taxes, 5 per cent depreciation on machinery, 1½ per cent on building	0.238
Insurance	0.004
Total indirect charges	0.586
Grand total cost per ton-day	$1.766

The author pointed out, however, that these costs were high owing to the type of machinery and the high rental. In a second, more modern, plant located in a low-rental building, the costs were about one-half those given.

Fred Ophuls, Consulting Engineer, in a paper on Manufacturing Expense in Ice-Making Plants, outlined a plan of accounting whereby the several items in the cost of ice manufacture may be segregated. He offered the novel idea that the cost of generating power in a large central station be taken as the standard whereby to gage the operating effort of the ice-plant engineering force.

Unfortunately, data on the segregated manufacturing expense of modern electric power plants were difficult to find. Taking advantage of the information it was possible to gather, it was decided for the present to divide the electric power cost into its items of manufacturing expense according to the following percentages:

	Per cent
Salaries and wages, power house	23
Fuel	30
Oil and waste	2
Sundries	2
Machine repair, labor	6
Material	6
Taxes	2
Insurance	2
Depreciation	27

This segregation of the electric-power cost must vary somewhat when electric power was purchased from various public-service companies. In all these first attempts it was better to start with something, however incomplete the data might be. When it was found that such a segregation of electric-power cost was valuable for this analysis, the power companies might help to prepare schedules themselves for this purpose.

The author then gave tables showing an analysis of costs in steam and electrically driven plants.

A comparison of the figures in the tables shows conclusively that an adjustment of the actual operating expense was necessary in order to make it comparable among several plants, particularly when one wished to compare steam-driven and electrically driven plants. Such a comparison was justified, and there should be means and ways by which this comparison could be made. Such a comparison would show very clearly why there was such an advantage in electrically driven plants, provided the current could be purchased at a reasonable cost.

T. K. Sherwood, Department of Chemical Engineering, Massa-

chusetts Institute of Technology, discussed The Economic Balance in the Design and Operation of the Ammonia Condenser.

The author's purpose was to establish the relation of the heat transfer to the water velocity in ammonia condensers, and thereby deduce the influence of the amount of water and scale upon the tonnage output of the condenser. It was pointed out that the resistance due to scale was constant, regardless of the water rate, and that as the condenser tubes became more and more scaled or corroded, the resistance to heat transfer continually increased, so that for the same load the temperature difference in the condenser must be increased, causing a corresponding increase in head pressure and in compressor horsepower. In the course of two or three months the heat transfer coefficient might be reduced to considerably less than half the value obtained when the tubes had just been scraped. This meant that, unless the load was reduced or the water rate increased, the necessary temperature difference must be more than doubled, causing an increase in compressor horsepower.

The temperature difference might be reduced by cleaning the condenser, causing a corresponding reduction in power requirements, and a balance must be struck between the power saving and the cost of cleaning. The determination of the optimum cleaning cycle had been worked out for the case of power-plant condensers, but so far as the author was aware, its importance had never been emphasized for the case of the ammonia condenser. A formula for the determination of the optimum time between successive cleanings was given.

A number of factors affected the determination of the optimum water rate for the condenser, and no simple formulas could be written for the total costs. As the water rate was increased, the necessary temperature difference was decreased, owing to the reduction in the overall resistance to heat transfer.

A series of highly interesting papers were presented at a session devoted to the subject of heat transmission (Joint meeting with The American Society of Mechanical Engineers; program arranged by Committee on Heat Transmission of the National Research Council).

Scope and Program of Committee on Heat Transmission, National Research Council.

By Comfort A. Adams, Mem. A.S.M.E., Professor of Engineering, Harvard Engineering School, Harvard University, Cambridge, Mass.

Status of Heat-Transmission Data and Knowledge in the Refractory Field.

By P. Nicholls, Heat Transmission Engineer, U. S. Bureau of Mines, Pittsburgh, Pa.

Determination of the Thermal Conductivities of Insulation for Temperatures up to 1000 Deg. Fahr. of Other than Flat Surfaces.

By R. H. Heilman, Assoc-Mem. A.S.M.E., Senior Industrial Fellow, Mellon Institute of Industrial Research, Pittsburgh, Pa.

Heat Transmission from Condensing Steam to Water in Surface Condensers and Feedwater Heaters.

By W. H. McAdams, Mem. A.S.M.E., T. K. Sherwood, and R. L. Turner, Associate Professor, Research Associate, and Instructor, respectively, Department of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

Heat Transfer for Forced Flow of Air at Right Angles to Cylinders.

By E. L. Chappell, Research Associate, Research Laboratory of Applied Chemistry, Department of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, Mass., and W. H. McAdams.

Methods That Have Been and Are Being Used for Measuring Heat Transmission.

By F. G. Hechler, Assoc-Mem. A.S.M.E., Professor of Engineering Research, Pennsylvania State College, State College, Pa.

The Guarded-Plate-Heater Method of Testing Low-Temperature Insulators Compared with Several Box Methods.

By E. F. Grundhofer, Pennsylvania State College, State College, Pa.

Method of Determining the Total Transmission of Building and Insulating Materials for Built-Up Walls.

By F. G. Hechler.

(An account of the meeting has also been published in *Power*, December 14, 1926, pp. 913–914.)

The Lincoln Award for the Best Paper on Arc Welding

The A.S.M.E. has accepted the custody of $17,500 to be awarded by the Society in a world competition for the papers descriptive of the greatest improvement in the art of arc welding submitted during 1927. This fund, provided by the Lincoln Electric Company, will be bestowed in three Lincoln Arc Welding Prizes, a first award of $10,000, a second of $5000, and a third of $2500.

The fund was accepted at the meeting of the Council on Friday, December 10, 1926. J. F. Lincoln, vice-president of the Lincoln Electric Company, presented the matter in person, and in doing so pointed out that the prizes are offered with the sincere desire to promote the whole art of arc welding and to reduce the cost of carrying out mechanical designs and construction.

The prizes are to be administered by the Council of The American Society of Mechanical Engineers, who will invite qualified experts to assist them. Complete information can be obtained by application to the Secretary of the Society. A more extended statement of the conditions of award of the prizes is being prepared; in the meantime the following information will serve for the guidance of prospective contestants.

Conditions of Award of Prizes

1 The award to be made for the year 1927 as soon after January 1, 1928, as practicable.

2 Any one in any country of the world may try for these prizes, but papers must be submitted in the English language.

3 The papers in competition are to be supplied in duplicate to the Council of the A.S.M.E., addressed to its Secretary, Calvin W. Rice, 29 West 39th Street, New York, before January 1, 1928. Any delay thereafter will exclude a paper from the competition.

4 To assist authors in the preparation of papers for this competition, the following conditions are added:

(*a*) The paper should include drawings of the design and careful description of apparatus needed to carry out ideas of the writer.

(*b*) The utility of the suggestions must be shown not only for the application but also for possible use in connection with other design and for their purposes.

(*c*) The economic saving to the industry—and therefore to mankind—by the use of the methods suggested should be pointed out.

(*d*) A demonstration of the practicability of the process and design is necessary. It is not necessary, however, that the actual application of this suggestion be fully shown, if a clear statement is made of possible uses.

(*e*) Originality of design is preferable either in the method of applying the weld or in the design of the welding parts for their arrangement. Designs which are of no practical use will be considered only in case they include suggestions which could self-evidently be applied in other ways than those suggested.

(*f*) Methods of applying the arc or the welding art which will improve existing machines or make commercially possible machines which in the light of previous engineering have been regarded as impractical, are specially desired.

(*g*) It is not necessary that all parts of the structure should be made of welded metal. It is only necessary that one or more parts be so made.

(*h*) Although it is stated that the limit of time will be January 1, 1928, it will be well to submit papers in competition as soon as they are prepared, that is, as early as possible in the year. In case two or more identical suggestions are received, the one arriving in the hands of the Secretary of The American Society of Mechanical Engineers first will have precedence over those following.

(*i*) It is recommended that the small amount of literature available be studied to get the fundamental principles which govern redesign. Numerous articles have appeared in the trade journals which will be valuable, and certain companies have done much work that will be helpful in getting out a paper.

5 The Council of The American Society of Mechanical Engineers may withhold any or all awards.

6 To facilitate filing and transmitting, it will be necessary that the paper be typewritten on one side of paper $8^1/_2 \times 11$ inches, bound at the top with covers that will protect it. The name and address of the sender should appear on the front cover, and if possible a brief statement of his qualifications should be included with the letter of transmittal.

American and European Engineers Discuss Bituminous Coal at Pittsburgh

THE International Conference on Bituminous Coal held at the Carnegie Institute of Technology, Pittsburgh, November 15–18, deserves the respectful attention of mechanical engineers as the first broad attempt by specialists to consider the subject of bituminous coal in all of its manifold aspects. The day has passed for coal to be looked upon merely as a material for burning on the grate. There was a time when coal tar was largely a nuisance at gas works. Then came the synthetic chemist, and under his expert manipulation coal tar became the origin of numberless products—dyes, medicines, perfumes, solvents, explosives, intermediary chemicals of key importance for national life. It looks as if a somewhat similar fate is in store for bituminous coal.

The subject, of course, is essentially not at all new. Gas with its by-products has been produced from coal for generations. The by-product coke oven is also not a recent development, but it is only within a comparatively modern time that an earnest attempt is made to break away entirely from the traditional coal burning on the grate and to replace it by other methods. One such method, burning the coal in pulverized form, has already attained a recognized and growing importance in the industry. Other methods are largely being developed, particularly in Europe, under the influence of an increased demand for liquid fuel for motor cars.

The following is an outline of some of the papers presented before the conference, abstracts of other papers being found elsewhere in this issue.

Development in Low Temperature Distillation at Fairmont, W. Va., by C. V. McIntire. Fairmont experimental plant of Consolidation Coal Products Company manufactures an artificial anthracite from soft coal by distilling soft coal at low temperature, briquetting the residue and heat treating the briquets. The process, the fuel, and by-products are described.

Smokeless Fuel, by O. P. Hood. The meaning of the phrase "smokeless fuel" is developed and illustrations are given of such fuels, with their various characteristics, and the conditions contributing to smokelessness.

The Piron Coal Distillation Process, by Emil H. Piron. The paper gives pertinent operating data from the two units erected by the Ford Motor Company. The mechanical difficulties attending the operation are described and complete data relating to five runs of variable duration is given. Mention is made of an improved unit now being designed to be erected in Italy.

The Transportation of Coal in Oil by Means of Hydrogenation, by Dr. Friedrich Bergius, Germany. The Process of Coal Liquefaction discovered by Dr. Bergius in 1913 has now been perfected so that from 50 to 60 per cent of the coal can be transformed into oil by hydrogenation under high pressure.

One ton of bituminous coal will yield an average of 140 gallons of oil. Deducting the coal consumed in the process the net yield is 104 gallons per ton of coal. Of this, 35 gallons consist of aromatic compounds, suitable for "no knock" motor fuel, and the remainder is gas-oil, lubricating oil, and fuel oil. The problems of high pressure, continuous feeding of coal, removal of residue, and temperature control have been solved. A method of manufacture of hydrogen has been worked out employing the gaseous by-products in the liquefaction of the coal itself. Except anthracite, nearly all grades of lignite and coal, especially screenings, can be liquefied.

The Synthesis of Petroleum, by Dr. Frans Fischer. The earlier work on the low-temperature distillation of coal, peat, and shale is reviewed. The Bergius hydrogenation-decomposition of coal is then taken up. After discussing older research on the synthesis of higher molecular weight hydrocarbons from lower ones, Savatier's work on the reduction of carbon monoxide is discussed. This leads up to Fischer's work on the hydrogenation of carbon monoxide with certain catalysts to produce synthol. The methanol synthesis from carbon monoxide and hydrogen and its relation to the synthol process is explained.

Coal-Tar Disposal, by John Morris Weiss. The subject is treated along commercial rather than theoretical lines. The author considers the magnitude of the by-product tar in the United States, its value in relation to domestic gas and steel, and the present usual channels through which it is disposed or marketed. Consideration is given to the problems of the tar producer in attempting to determine whether it is more advantageous to sell his tar production or install a distilling plant and operate it for the production of certain primary products.

The probable outlets for the low-temperature tars of the future is discussed and the rather extravagant claims as to tar value made by some promoters of low-temperature carbonization processes are questioned. It is the belief of the author that any estimates of tar value above the value of liquid fuel are unsound under present conditions if large tonnages are produced.

Practical Value of Research on Coal, by A. C. Fieldner. The practical value of fundamental research on the composition and constitution of coal in relation to its combustion, oxidation and carbonization is shown. Attention is called to the higher form values of liquid and gaseous fuels and the limited supply of natural gas and petroleum. Fundamental research will point the way toward the economical conversion of raw coal to augment and replace the waning supply of gas and petroleum. Such research will hasten the day of smokeless fuel when the atmosphere of our cities will become free from smoke, thus eliminating a source of economic loss.

British Research on Fuel Utilization, by C. H. Lander. The paper commences with a very general survey of the activities of the various bodies in England which are dealing with the question of the pretreatment of coal. It then goes on to discuss, very much more in detail, the work of the Fuel Research Division of the Department of Scientific and Industrial Research, of which Dr. Lander is the director.

Powdered Coal, by Henry Kreisinger. The paper deals with the following subjects:

Burning Powdered Coal in Refractory Lined Furnaces; Slagging of Ash, Errosion of Furnace Lining; Flames Must Not Impinge Against Walls; Turbulence Limited; Rate of Combustion Low on Account of Limited Turbulence; Large Furnaces.

Burning Powdered Coal in Water-Cooled Furnaces; No Danger From Erosion of Walls; Difficulties with Slagging Ash Greatly Reduced; Flames Impingement Permissible; Intense Turbulence Possible; Mixing Produced by Turbulence Causes Quicker Combustion; Higher Rates of Combustion Possible, Resulting in Smaller Furnaces.

Methods of Creating High Turbulence; Introducing Coal and Air in Streams Tangential to a Circle in Center of Furnace and Causing Rotary Motion of Furnace Gases; Wood's Steam Generator; Introducing Secondary Air Under Pressure Through Burner in Such a Way as to Produce Rotary Motion of Furnace Gases; Couch Burner; Rate of Heat Generation up to 40,000 B.t.u. Per Cubic Foot Combustion Space Per Hour.

Mouth of Mine Power Stations, by Geo. A. Orrok.

1 The location of every generating station is a separate problem in which many factors must be taken into consideration.

2 Under normal conditions, the building of mine-mouth central stations will be limited to those localities where a sufficient and reasonably good water supply may be obtained and where the market is sufficiently close at hand to avoid high transmission cost.

3 Poor fuels as lignite, peat, or waste coal cannot generally compete with good coals.

4 Cooling towers or spray ponds may be commercial under some conditions, but in general transmission costs are lower than cooling-tower costs plus loss of station efficiency.

5 Given a sufficient return from by-products a combination low-temperature distillation plant and generating station may be commercial with a high-load-factor market.

6 At present writing, however, no central station with restricted water supply has shown good commercial economy. Those plants using good coal, plenty of condensing water and located in proximity to markets have given the best commercial and thermal results.

Book Reviews and Library Notes

THE Library is a coöperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E. and the A.I.E.E. It is administered by the United Engineering Society as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Wanted: Books Dealing with the History of Engineering

THE United Engineering Societies library is, as is well known, the most complete library on engineering subjects in the world. Among other features it has an interesting collection of books on the history of engineering which it is anxious to better, for it finds considerable demand for such books—and few subjects are more alluring to the technical man. The library has, however, but a small fund with which to purchase books, and this fund must necessarily be used in the purchase of such new books as from time to time appear on engineering subjects. Quite a number of engineers have interested themselves during the course of their professional career in collecting books upon the history of engineering. These books are usually of little interest to the family of the engineer, and, although they may have cost the owner a relatively large sum of money, can seldom be disposed of with much advantage to the estate. This condition has suggested to the Library Board a possible method of augmenting its collection of works dealing with the historical side of engineering. It is requested that those engineers who have collections of books on the history of mining, metallurgy, or other branches of engineering, get in touch with Sydney H. Ball, Chairman of the Library Board, or Harrison W. Craver, Director, Engineering Societies Library, and indicate their willingness to bequeath to the Library their books upon the history of mining or other branches of engineering. The library proposes to keep a card catalog of such bequests. If the owners of books on the history of engineering feel disposed to coöperate with the Library Board in this way, the Library's historical collection can be gradually and greatly strengthened.

Education Through Woodworking

EDUCATION THROUGH WOODWORKING. A Series of Essays. Yates American Machine Co., Beloit, Wis., Rochester, N. Y., and Toronto, Ont. Cloth, 354 pp., illus., diagrams, charts. $5.

THIS interesting volume, from the press of the Educational Department of the American Woodworking Machinery Company (succeeded by the Yates American Machine Company), contains a series of prize-winning essays as well as practical hints on the operating of woodworking machines, and also floor plans and machine specifications for woodworking departments. The contributions were largely prepared by directors, teachers, and instructors in the woodworking and manual-arts departments of universities, colleges, high schools, and technical institutes. Prizes aggregating $10,000 were awarded for these articles, and twenty-two were chosen from the thousands submitted and published in book form.

The material is most suggestive for those who are interested in developing an improved artisanship and a better handicraft work in the intimate school relationships of our growing boys and girls.

The chapter on Wood—A Basic Material, by Frank H. Shepherd, Director of Educational Rehabilitation, Oregon State Agricultural College, Corvallis, Oregon, is particularly instructive since it argues most persuasively for the perpetuation of wood and wood equipment in contrast with the various substitutes that are now offered. The article by George B. Cox, Instructor of Industrial Education, University of Wisconsin, on Training Leaders in Industry, is also particularly in line with the activity of the Wood Industries Division of The A.S.M.E., since it pictures quite graphically opportunities that exist for boys who want to become executive and administrative officers in the larger wood-utilization plants of the country.

While the purpose of the book is frankly the promotion of the educational demand for woodworking machinery, the compiler has nevertheless taken a broad viewpoint and the volume is of far greater value for the reference library than is usually the case with such works. Copies of the book are available at the reduced price of $2.50 to those engaged in woodworking industry or instructors of woodworking.

THOMAS D. PERRY.[1]

Books Received in the Library

AIRMEN AND AIRCRAFT. By Henry H. Arnold. Ronald Press Co., New York, 1926. (Ronald Aeronautic Library.) Cloth, 6 × 9 in., 216 pp., illus., diagrams, $3.50.

A general descriptive book, written in simple, non-technical language. The author describes the various kinds of aircraft and their uses, explains the training of aviators in the Army and private schools, gives some notes on famous flights and noted fliers, and discusses the future of aviation.

BOOK OF THE AEROPLANE. By Capt. J. Laurence Pritchard. Longmans, Green & Co., New York and London, 1926. Cloth, 5 × 8 in., 255 pp., illus., $2.75.

A good book for the general reader who wishes to be informed on the past and present of aviation. Mr. Pritchard discusses such topics as the early history, famous flights, races, the various types of airplanes and seaplanes, airplane engines, how airplanes fly, commercial and military uses and future development. The style is interesting, and technicalities of slight interest to the general public are omitted.

CHEMISCHE TECHNOLOGIE DER LEICHTMETALLE UND IHRER LEGIERUNGEN. By Friedrich Regelsberger. Otto Spamer, Leipzig, 1926. 7 × 10 in., 385 pp., illus., portraits. Paper, 26 r.m.; bound, 29 r.m.

Dr. Regelsberger's monograph is a convenient summary of our knowledge of the light metals, based on a thorough expert examination of the literature to the end of the year 1924. He discusses their occurrence in nature, history, physical and chemical properties, alloys and compounds, metallurgy, preparation for use, and their uses. A chapter is given to statistics and trade conditions. Lists of the important patents, European and American, are included. The metals included are lithium, potassium, sodium, rubidium, calcium, magnesium, caesium, beryllium, strontium, aluminium, and barium.

CHEMISTRY IN THE WORLD'S WORK. By Harrison E. Howe. D. Van Nostrand Co., New York, 1926. Cloth, 6 × 9 in., 244 pp., illus., $3.

Dr. Howe has written an interesting account of the part that

[1] Director Woodworking Division, Bigelow, Kent, Willard & Co., Inc., Boston, Mass. Mem. A.S.M.E.

chemistry has played in bringing the world to the present level of civilization. He indicates in broad outline what the chemist has contributed to such important topics as food, clothing, structural materials, health and communication, together with others of less vital importance. The book is primarily for those not technically trained, but nevertheless will interest others whose experience does not cover the whole field of human effort.

DIE DAMPFKESSEL, vol. 1; Kesselsysteme und Feuerungen. By Friedrich Barth. Walter de Gruyter & Co., Berlin and Leipzig, 1926. Cloth, 4 × 6 in., 142 pp., illus., diagrams, 1.50 r.m.

A brief introduction to the subject of steam generation and the steam boiler, based on scientific principles but couched in non-technical language. This volume discusses the general principles, the theory of combustion, methods of firing, heat conduction and heat losses, systems of boilers, and steam economy.

THE DIVINING-ROD. By Sir William Barrett and Theodore Besterman. Methuen & Co., London, 1926. Cloth, 6 × 9 in., 336 pp., illus., 18s.

This is a very interesting book on the art of dowsing. The authors have examined the literature, have collected and examined critically a substantial number of contemporary cases and have carried out experiments designed to test the claims made on behalf of "water divining." They trace the belief back to antiquity, describe the activities of some of the notable dowsers of today and discuss the mechanism and the rationale of dowsing. The book has numerous illustrations and good bibliography.

As a result of their investigation, the authors conclude that dowsing is not mere superstition. Certain individuals, they believe, have a subconscious supernormal faculty that enables them to discover the location of underground water, ores, metals, and other substances.

ELECTRICAL MACHINE DESIGN. By Alexander Gray, revised by P. M. Lincoln. Second edition. McGraw-Hill Book Co., New York, 1926. Cloth, 6 × 9 in., 523 pp., illus., diagrams, $5.

The reviser has retained Professor Gray's presentation of fundamental principles and his methods of analysis without modification. He has taken account of the development that has occurred in electrical machinery in the past fourteen years, and has modified the example machines so that they represent current designs, and changed the various curves, tables, illustrations, and other data to conform with present practice.

ELEKTRISCHE ZÜNDUNG, LICHT UND ANLASSER DER KRAFTFAHRZEUGE. By E. Seiler. Wilhelm Knapp, Halle (Saale), 1926. Paper, 7 × 10 in., 169 pp., illus., 7.60 r.m.

An extensive discussion of the electrical equipment of the automobile. Treats of ignition, starting, signaling, and lighting, describing the theory and construction of the apparatus used for these purposes. The book is intended primarily for repairers and owners, but will also interest manufacturers.

ELEMENTARY HEAT AND HEAT ENGINES. By F. G. R. Wilkins. Oxford Univ. Press, London and New York, 1926. Cloth, 5 × 8 in., 312 pp., illus., diagrams, tables, $2.50.

Suited to the needs of students in trade schools and technical institutes, and of those interested in allied branches of science who wish a general insight into the principles underlying the operation of heat engines.

ELEMENTS OF AEROFOIL AND AIRSCREW THEORY. By H. Glauert. Cambridge University Press, 1926. Cloth, 6 × 9 in., 228 pp., diagrams, tables, $5.60.

The aim of aerofoil theory is to explain and to predict the force experienced by an aerofoil; and as the airscrew blades are aerofoils, the problem of the airscrew is essentially a part of the theory. Although the theory is at present incomplete, certain portions have been developed to a usable point, and from the fundamental principles a satisfactory theory of the propulsive airscrew has been developed.

The aim of the present book is to give an account of aerofoil and airscrew theory in a form suitable for those who have no previous knowledge of hydrodynamics. A brief introduction to the aspects of hydrodynamics which are required for the development of aerofoil theory is given, followed by chapters on the lift of an aerofoil, the effect of viscosity, aerofoil theory, and airscrew theory.

ELEMENTARY STEAM ENGINEERING. By E. V. Lallier. Second edition. D. Van Nostrand Co., New York, 1926. Cloth, 5 × 8 in., 288 pp., illus., diagrams, $2.50.

An elementary textbook intended for use in technical schools, apprentice schools, etc. The treatment is non-mathematical and is intended to give the operating engineer a practical acquaintance with the fundamental principles of steam engineering.

ELEMENTS OF HEAT-POWER ENGINEERING, VOL. 1; Thermodynamics and Prime Movers. By William N. Barnard, Frank O. Ellenwood, and Clarence F. Hirshfeld. Third edition. John Wiley & Sons, New York, 1926. Cloth, 6 × 9 in., 493 pp., illus., diagrams, tables, $4.50.

This is a new edition of the portions of Hirshfeld and Barnard's Elements of Heat-Power Engineering which relate primarily to thermodynamics and the elementary principles of prime movers. In preparing it the authors have found it necessary to rewrite practically all of the text, in order to incorporate new methods of treatment and to include new material. The new edition is intended as a text for a full year of instruction, and the authors also believe that it will be of interest to practicing engineers as an account of recent notable advances in this field.

ELEMENTS OF MOTOR VEHICLE DESIGN. By C. T. B. Donkin. Oxford University Press, London and New York, 1926. Cloth, 6 × 9 in., 277 pp., diagrams, tables, $4.25.

A textbook on automobile design which demands of the reader an elementary knowledge of mechanics and practical mathematics and a general acquaintance with the mechanism of a motor car. On this basis, it develops the subject from first principles and teaches the student to apply the theory to practical design. The book covers the problems that are encountered in the drawing office and the factory.

ENGINEERING METALLURGY. A Textbook for Users of Metals. By Bradley Stoughton and Allison Butts. McGraw-Hill Book Co., New York, 1926. (Metallurgical Texts.) Cloth, 6 × 9 in., 441 pp., illus., diagrams, tables, $4.

This textbook covers a broad field in a concise fashion. Starting with an account of the physical and mechanical properties of metals, the reader is introduced to the current methods of examining and testing them. The occurrence of metals in nature and the general methods of obtaining and refining them are then described. Chapters follow on electrometallurgy, on the mechanical working of metals and on alloys, after which the properties and uses of the various metals, and the processes for producing and refining them are given individual treatment. The remainder of the book discusses corrosion, fuels and combustion, slags, fluxes, refractories, pyrometry, and heat transfer and heat losses in furnaces.

The book is a good introduction to the subject for those who intend to specialize in it, but its primary purpose is the instruction of those who, as mechanical or civil engineers, will be users of metals. The subject is therefore treated from the viewpoint of utilization, and emphasis is laid on the relation of the structures and properties of metals to their uses and the effects of working, impurities, and processes of production on their properties.

GEARS AND GEAR CUTTING, previously "Toothed Gearing," by Joseph Horner; revised by Philip Gates. Crosby Lockwood & Son, London, 1926. Cloth, 5 × 7 ins., 139 pp., illus., diagrams, tables, 5s.

This modernization of Horner's Toothed Gearing has been thoroughly carried out. The result is a practical little manual on spur, bevel, worm, helical, and spiral gears, which describes clearly the design, cutting, and testing of these standard forms. While much of the original text is retained, much that is no longer useful has been omitted, and a considerable amount of new material has been added.

GEOMETRY OF ENGINEERING DRAWING: Descriptive Geometry by the Direct Method. By George J. Hood. McGraw-Hill Book Co., New York, 1926. Cloth, 5 × 9 in., 290 pp., diagrams, $2.50.

Presents a new method of teaching descriptive geometry, used by the author for the last six years. This method avoids the use of planes of projection, quadrants, etc., and directs attention to the object itself, in agreement with engineering practice.

Die Getriebekinematik als Rüstzeug der Getriebedynamik. By Friedrich Proeger. V. D. I. Verlag, 1926. (Forschungsarbeiten auf dem Gebiete des Ingenieurwesens, heft 285.) Paper, 7 × 10 in., 74 pp., diagrams, 6.70 r.m.

The study of kinematics has first become of considerable importance in practice during recent years, when it has proved helpful in solving many dynamic problems. A number of graphic processes have been developed here, but they have been adapted only for the specific problems. The present work is intended to show that a solution of dynamic problems in general can be obtained.

In the first part of this book the author treats of the principles of the kinematics of gearing. A systematic classification of gears permits a further schematic treatment of the speeds and accelerations of the individual gear points, and the graphic processes necessary for this are explained in detail.

In the second section this knowledge of the kinematics of gearing is applied successfully to the solution of important general problems in their dynamics, and makes possible, according to the author, reductions in the mass of the gear links without harm.

Giesserei Handbuch. By Verein Deutscher Eisengiessereien Giessereiverband in Düsseldorf. Second edition. R. Oldenbourg, Munich and Berlin, 1926. Cloth, 7 × 10 in., 413 pp., diagrams, tables, 18 mk.

This is not a textbook on founding but a practical handbook for the use of foundry managers and others interested in the trade. It contains much information on the specifications adopted by various official and trade organizations, at home and abroad, and on acceptance tests. Methods for testing raw materials and castings, and standards for castings are given. There is a list of all cast articles made by German foundries, and one of periodicals of interest to foundrymen. Statistics on production, prices, etc., are tabulated. The volume also contains directories of domestic and foreign associations of foundrymen, of German foundries and blast furnaces, and of foundry-supply dealers.

House Heating. By Margaret Fishenden. H. F. & G. Witherby, London, 1925. Cloth, 8 × 10 in., 296 pp., illus., diagrams, 25s.

A description of current practice in domestic heating in Great Britain. Dr. Fishenden discusses fuels, grates for living rooms, kitchen ranges, the use of gas and electricity for heating and cooking, and central heating. Her book describes the apparatus used in England and brings together in convenient form much information on the subject.

Hydrographic Office. By Gustavus A. Weber. Johns Hopkins Press, Baltimore, 1926. (Institute for Government Research. Service Monographs, no. 42). Cloth, 6 × 9 in., 112 pp., $1.

A descriptive study of the Hydrographic Office. Traces its history, explains its functions, describes its organization and plant for fulfilling them, and gives information on the laws that govern it and on its cost.

Hütte; des Ingenieurs Taschenbuch, Bd. 2. By Akademischer Verein Hütte. Wilhelm Ernst & Sohn, Berlin, 1926. Cloth, 5 × 7 in., 1167 pp., illus., diagrams, tables, 14.70 r.m.

The second volume of this twenty-fifth edition of Hütte, devoted to mechanical engineering, shows a thorough revision and rearrangement. Among the novelties are rewritten sections on gears and gearing in the chapter on machine elements. The chapter on prime movers contains a new section on the "living motor," and new data on wind turbines, steam plants, steam engines and turbines, internal-combustion engines; hydraulic turbines, and gas turbines. In the division on machine tools the data on welding, woodworking, compressed air, and forging machines have been revised. The sections on methods of lifting liquids, on blowers and on compressors, have been rewritten. The remaining divisions, treating of illumination and of electrical engineering, have also been revised and extended.

Industrial Safety Organization for Executive and Engineer. By Lewis A. De Blois. McGraw-Hill Book Co., New York, 1926. Cloth, 6 × 9 in., 328 pp., illus., tables, $4.

This is an attempt to deal intimately and at length with the basic principles of safety organization. It summarizes, in a way, the profuse amount of information scattered through periodicals, codes, rule books, bulletins, etc., and presents a connected account of the subject. The author writes from the background of fourteen years of accident-prevention work in the Du Pont Company.

Der Industriestaub, Wesen und Bekämpfung. By Robert Meldua. V.D.I. Verlag, Berlin, 1926. Cloth, 6 × 8 in., 301 pp., illus., tables, 14.50 r.m.

An attempt to summarize the scattered information on the handling of industrial smoke and dust. The author discusses the properties of dust, its dangers, and the methods for its prevention or collection. Mechanical and electrical methods are described, and also methods for transporting and disposal. Chapters are included on dust explosions, on methods of measuring dust, and on preventive measures. A bibliography is included.

Der Kreisrunde Ueberfall und Seine Abarten. By A. Staus and K. v. Sanden. Mün. & Ber., R. Oldenbourg, Munich and Berlin, 1926. (Sonderabdruck aus *Das Gas-und-Wasserfach*, heft 27–30, July, 1926.) Paper, 6 × 9 in., 39 pp., diagrams, tables.

Among the various forms of weirs which are available for measuring the flow of large amounts of water along open channels, that which is easiest to set up, the weir with a completely circular opening, has hitherto been used very infrequently. The neglect of this form in spite of its good hydraulic qualities is probably due, in the opinion of these authors, to rather difficult theoretical treatment, upon which exact knowledge has previously been lacking.

The authors have undertaken to remove the difficulty by developing thoroughly the theory of the circular opening and carrying out a series of experiments with it and other forms of openings. The results are given in the present report. It develops the exact theory of the circular opening, extends the theory to semi-circular, concave, and convex notches, gives a theory of errors that is applicable to notches of any form, and presents the results of the experimental tests carried out by the authors.

Kupfer. By U. S. Bureau of Standards. Translated by P. Siebe. Issued by Deutscher Gesellschaft für Metallkunde. V.D.I. Verlag, Berlin, 1926. Paper, 6 × 8 in., 120 pp., illus., diagrams, tables, 5.60 r.m.

A translation of Circular No. 73 of the U. S. Bureau of Standards.

Les Progrès de la Fonderie Moulage et Fusion. By C. Derulle. Masson & Co.; Gauthier Villars & Co., Paris, 1926. Paper, 5 × 8 in., 256 pp., illus., diagrams, $0.88.

Not a treatise on foundry practice, but a review on broad lines of modern advances in founding and of the present state of the art. The author describes the methods of molding now in use, the furnaces, methods of casting and of finishing the castings. A chapter is devoted to foundry organization and cost-finding.

Technisches Woerterbuch—Des Maschinen und Schiffbaues, vol. 2; Englisch-Deutsch. By Erich Krebs. Second edition. Walter de Gruyter & Co., Berlin and Leipzig, 1926. Cloth, 4 × 6 in., 163 pp., 1.50 r.m.

A convenient English-German pocket dictionary of technical terms used in mechanical engineering and naval architecture. Apparently includes all the principal terms, with satisfactory equivalents, and is remarkably cheap.

Untersuchung Uber die Geschwindigkeitsverteilung in Turbulenten Stromungen. By J. Nikuradse. V. D. I. Verlag, Berlin, 1926. (Forschungsarbeiten auf dem Gebiete des Ingenieurwesens, heft 281.) Paper, 8 × 11 in., 44 pp., illus., diagrams, tables, 6 r.m.

Although the distribution of the velocities in turbulent flow is of great importance for its understanding and also for its theoretical investigation, the present research is, the author says, the first undertaken on this point. This work gives the results of experiments on the distribution of velocities in closed channels and also on the surface of open channels.

Part one describes experiments on turbulent flow in pipes with circular, triangular and rectangular sections, giving the apparatus used, the method, and the results. Prandtl's law is derived from the consideration of dimensions, and the degree to which it corresponds with experimental results is shown.

In part two, the distribution of velocities in an open rectangular channel and on its surface is investigated. A comparison of distribution in open and in closed channels ends the work.